Management Manual for

Productive R&D Project Planning, Monitoring and Evaluation

ICIPE

FINANCIAL AND ADMINISTRATIVE MANAGEMENT OF RESEARCH PROJECTS IN EASTERN AND SOUTHERN AFRICA (FAMESA)

A research and development (R&D) management training network of national R&D institutes, management and development training institutes, and councils of science and technology in Eastern and Southern Africa, based at the International Centre of Insect Physiology and Ecology, (ICIPE), P.O. Box 30772, Nairobi, Kenya

Management Manual for

Productive R&D Project Planning, Monitoring and Evaluation

March 1993

FINANCIAL AND ADMINISTRATIVE MANAGEMENT OF RESEARCH PROJECTS IN EASTERN AND SOUTHERN AFRICA (FAMESA)

A research and development (R&D) management training network of national R&D institutes, management and development training institutes, and councils of science and technology in Eastern and Southern Africa, based at the International Centre of Insect Physiology and Ecology, (ICIPE), P.O. Box 30772, Nairobi, Kenya

Originally produced in 1989 in temporary binding; first printing, March 1993.

ISBN 92 9064 072 3

Foreword

Research and development (R&D) institutes require to operate at two levels of planning: at the strategic policy level, and at the implementation level. **Strategic planning, at the policy level**, gives the project a sense of direction by establishing fundamental standards and basic resources by which it will be implemented while spelling out the policy implications related to the project. This level of planning is undertaken at the top of the R&D institute hierarchy. **Planning at the implementation level**, requires the scientist to prepare, within the general framework of the institutional strategic plan, a strategy for implementation, the development of a workplan and a plan of action.

The first publication in the series of the FAMESA Management Manuals for Productive R&D dealt extensively with strategic planning and budgeting. The **Manual** was addressed mainly to strategic managers and planners at the various levels of research management. The present **Manual**, on "R&D Project Planning, Monitoring and Evaluation", provides an insight into concepts and skills desired in the areas of project planning, monitoring and evaluation. These same areas are of critical importance for realizing the objectives of research programmes and projects in R&D institutes.

Some of the difficult tasks confronted by research managers and administrators include the proper definition of research goals, expression of scientific and operational plans arising from this characterization, measurement of performance, regulation of activities within given resources, and making decisions concerning choices and alternatives for resource expenditure. These issues are discussed extensively in the present **Manual.**

This publication is a product of invaluable inputs from scientists, national policy makers and science administrators. We are most grateful for their contributions. We wish to convey our sincere thanks to Professor J.H. Kimura, who wrote the text; and to express our appreciation to the various experts, particularly those from eastern and southern African region, for their critical review of the contents of the **Manual** and its validation.

Finally, FAMESA is thankful to its Coordinator, Dr. Zerubabel M. Nyiira, who took up the task of completing the preparation of this **Manual** and has coordinated FAMESA activities since the departure of his predecessor, Dr. Luka O. Abe, two years ago.

This **Manual** was produced with the aid of a financial grant from the International Development Research Centre (IDRC), Ottawa, Canada, for which FAMESA is profoundly grateful.

Professor Thomas R. Odhiambo
Director
International Centre of Insect Physiology and Ecology, ICIPE
Nairobi, Kenya

1st August 1989

TABLE OF CONTENTS

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

Introduction

INTRODUCTION

1. *Need for Management Training*

Introduction

This **Manual** is based on practical research experience by FAMESA on the management of RDIs in Eastern and Southern Africa and other developing countries. It represents a unique training experience. Needless to say, this **Management Manual for Productive R&D** will be adapted and revised by users to make it most applicable within each national system. But hopefully, the most basic design has proved sufficiently effective to justify the development and publication of other volumes covering the full range of RDI management topics. Hopefully, it will stimulate sufficient reaction to encourage international sponsors to join in this R&D management training venture.

Observations on R&D Management. Observations in research and development institutes (RDIs), and discussions with their managers during consultancies and training exercises led to three fundamental assumptions which had the greatest influence on the **Manual** approach to the subject of R&D management:

1. The greatest sense of need expressed by R&D managers was for strategic level planning and incremental budgeting which would be useful for the RDI as a whole, for R&D projects which are already underway, and for new projects which are particularly attractive for new funding.

2. Managers also appear to place considerable emphasis on providing R&D project leaders with the tools, techniques and orientation needed to plan, budget, monitor and control their own projects.

3. While the greatest need for management training among RDI managers is, therefore, a basic understanding and overview of management as a process which can enhance R&D productivity throughout the R&D institute, there is also a need to train them at the operation level.

The specific orientation in the current **Manual** is on project planning, monitoring and evaluation in the context of R&D Management.

Many RDI managers graduate to management positions from the ranks of technical specialists in charge of R&D projects. On the face of it, this would suggest that they are particularly responsive to the needs of R&D project leaders — and in fairness, we must conclude that some are. However, deficiencies in management experience and training often preclude their effectiveness in responding to these needs. Project leaders also face the same difficulty when dealing with project staff.

Further, their increased exposure to pressures and demands from controlling boards and granting agencies of the government, can distract their attention from the technical productivity of individual R&D projects and the resources, assistance and support needed by technical staff. Instead, it causes them to focus too much on such issues as the growth of the RDI they manage, growth in the R&D portfolio and influence and longevity in the science and technology infrastructure of the country.

These conditions exist not because of any deficiencies in desire for R&D to impact national development. Rather, they exist because of considerable misunderstanding about the role of organizations, management, and managers in any enterprise but particularly in the R&D enterprise. Therefore, this **Manual** presents management technology as a tool for R&D "productivity". It focuses on the desired results of R&D projects and programmes. It emphasizes the role of R&D in creating and distributing new technologies for national development.

Secondly, while the first **Manual** details management techniques in planning and budgeting, it (and all future ones) will do so in a more general context of management as a collection of tools for improving R&D productivity. Therefore, for example, each **Manual** will start with an overview of R&D management and will relate its particular skill emphases to the whole management process.

Pedagogical Considerations. Part of the uniqueness of this R&D management training venture lies in the pedagogical standards adopted for each **Manual.** They derive from experiences in designing, writing and delivering long and short-term training to R&D managers in developing economies as well as familiarity with training materials developed by others in this business. Five particular standards have been applied to the development of these **Manuals:**

1. **Mediated and Self-Instructional:** The **Manual** must be amenable to stand up to delivery by skilled trainers. But, it must also be amenable to self-instruction.

2. **Experiential:** The **Manual** must provide motivation and opportunity for trainees to practice key management technologies by solving realistic training problems and exercises.

3. **Visual:** The **Manual** must provide visual stimuli for both mediated and self-instructional modes of delivery.

4. **Interactive:** The **Manual** must stimulate, structure and process mutual problem solving discussions, not only between trainees and instructors, but among trainees themselves.

5. **Empirical:** The ideas and concepts introduced by the **Manual** must be selected on the basis of real observations about management practices and problems in Third World RDIs. Further, they must be presented in the same terms.

The first criterion, **mediated and self-instructional,** derives from the feeling that needs for training in R&D management are widespread. Therefore, it is wasteful to develop materials which are only meaningful and available to a few R&D managers, fortunate enough to be selected for a workshop.

Further, few materials developed for past courses and workshops are practical for review purposes by workshop participants — much less practical for participants to share with colleagues who could not participate in the training. We desire to overcome these limitations with the **Management Manuals for Productive R&D.**

The fourth criterion, interactive, stems from a sense that RDI participants fail to see the value for sharing their management problems and jointly seeking solutions to them either between RDIs within countries, or between countries. Of course, there is the sectoral bias, that is, their feeling that a manager from an RDI in one sector (like agriculture) has nothing to offer a manager from an RDI in another sector (like industry). There is also a socio-cultural bias which inhibits managers of one culture from sharing with, and learning from, managers of another.

It is therefore, important for the **Manual** to demonstrate that all trainees have a great deal to offer each other. It must, therefore, stimulate them to share and solve their management problems together. One of the greatest long-range impacts of this **Manual,** and its companions, would be the generation of a worldwide network of R&D managers who actively seek each other's ideas and solutions to management problems they encounter in the course of their work.

The fifth pedagogical criterion, **empirical,** stems from the feeling that attempts to transfer management technology from business schools, or RDIs, in industrialized countries, to RDI managers in developing countries is ineffectual if not inappropriate, unfair and insensitive. Many management techniques developed in Europe or the United States simply do not apply in the context of real RDI problems and opportunities.

We have adopted two strategies for accomplishing this. On the one hand, the **Manual** requires participants to apply the concepts to their own RDI problems. All participants in training with these **Manuals** are encouraged to bring for these purposes:

1. Their country's current development plan, if available.

2. Current statements of their country's science and technology policies.

3. The mandate statement for the institution they represent.

4. The current organization chart for their own institution.

5. Examples, from their own institution, of R&D projects, proposals, budgets and such final reports as they may be able to collect.

Many of the exercises in the **Manual** call for the participants to apply management principles to their own R&D institutions. These documents will greatly enhance the value of these exercises and the transfer of sound R&D management principles to real R&D settings.

The second approach to the requirement that R&D management training be based on the real needs, priorities and pressures experienced by R&D institutions in the Third World is fulfilled through the process used to develop the **Manual.** R&D management curriculum specialists visited a variety of such institutions in many countries prior to outlining the parameters of this **Manual.** Further, they integrated their observations in the body of the text so that trainees can see how the management concepts relate to the real experiences. Finally, the whole **Manual** is critically reviewed and evaluated by a team of R&D and management specialists from several countries. Their work leads to a major revision of the manual.

Partners in R&D Management Training. If these strategies are successful, we expect demand to increase for RDI management training provided by instructors who are trained to use these **Manuals.** Further, we expect demand for use of them in the self-instructional format. It is likely that RDIs will also organize their own training programmes, using the **Manual** as a basis for instruction. In other words, the opportunity exists, through a mechanism like this, for the R&D managers of the world to become partners in an effort to make dramatic improvements in the conduct, and ultimately, impact, of R&D on national development.

2. *Purposes of the Manual*

This **Manual** focuses on management concepts and practices which will enhance project planning, monitoring and evaluation in R&D institutes. It is targeted on R&D managers at both the management and operational levels of the RDI.

Therefore, it will be helpful to a wide variety of R&D managers. In fact, we would encourage its use in workshops comprised of participants from diverse, (1) sectors of the economy, (2) levels of technical sophistication, (3) management experience, (4) career status, and (5) R&D roles and responsibilities.

The **Manual** is designed to help R&D managers:

1. Understand the vital role of R&D in national development;
2. Comprehend the special character of management in R&D projects and programmes;
3. Realize the need for optimal organizational structures and styles of management for productive R&D work;
4. Perform R&D planning at both the institute and project levels;
5. Design budgets for R&D projects;

6. Recognize the role of the R&D proposal as the first attempt to pool together all critical elements of R&D planning;

7. Learn to apply plans and budgets to the process of ensuring that R&D work is productive, i.e., does have a desirable impact on economic development; and

8. Learn to apply various techniques in project evaluation and review.

For these purposes, the **Manual** is divided into the following ten parts:

INTRODUCTION

CHAPTER I: **Planning as a Management Function**

CHAPTER II: **Project Planning for RDIs**

CHAPTER III: **Project Generation and Project Proposals**

CHAPTER IV:
Part I **Project Monitoring, Control and Evaluation**
Part II **Technical Performance**
Part III **Schedule Performance**
Part IV **Cost Performance**

CHAPTER V: **Project Termination**

CHAPTER VI: **Post Completion Project Evaluation**

Each chapter is headed by a content outline and learning objectives. They will be useful for instructors who are planning the agenda for a programme of instruction. This is a stand-alone self-instructional package with an inherent motivated sequence which should both stimulate and control the pace and quality of learning. Further, it is designed for easy adaptation to mediate instructions in a workshop setting.

3. *Instructions for Users*

Introduction: Welcome to the Management Manual for Productive R&D. We hope that it will enhance your R&D management skills and be a pleasant learning experience.

Individual and Group Learning: The **Manual** is designed for either individual or group learning. It is self-instructional for the R&D manager who is studying independently. But it is also amenable to group learning; for use in workshops and other training contexts. It may be used by a manager participating in a large workshop, and then re-used as that manager shares it with a colleague back in the office. It was designed to make the most learning possible in the greatest variety of formats.

Exercises: Every now and then you will find exercises which help the R&D manager practice the ideas and concepts being discussed. These exercises may be conducted in a variety of ways: individually in the self-instructional mode; over-night as homework during a mediated workshop; in teams during class time; or even in plenary.

Instructor(s) Notes: Occasionally there are notes to the Instructor(s), designed to help them plan and deliver a workshop, in the mediated mode. If the **Manual** is being used in the self-instructional mode, these may, and should, be ignored. Otherwise instructor(s) may find them helpful in organizing the workshops.

Chapter Guides: At the beginning of each Chapter or part of a chapter, there are some guiding materials. These give information which will help you plan your study. The first one is simply a title page. The second, however, presents the learning objectives for all the information contained in the Chapter. It will give you an idea of what you should be able to do after you have learned all that is in the Chapter.

The third page is a Table of Contents for the Chapter. It is like any other Table of Contents except that it includes notice of a — **Session Break** — wherever we think it would be helpful to divide the material into successive days of workshop sessions. It also shows the index numbers assigned to principal paragraphs in each Chapter. These numbers are designed to help you direct your study and discussion with other fellow participants.

Length of Sessions: A workshop planned for a group of R&D managers should run for 5–10 days of instruction. Some of the **Manual** Chapters comprise one-day sessions. Others are two or three-day sessions, depending on the pace set by participants and instructor(s).

Basically, we encourage half-day sessions during which new material is introduced. It usually works best to introduce new material in the morning. Then the afternoon is a good time for group exercises and field trips. This takes advantage of the participants' natural tendencies to be more alert and rested in the morning. Regardless, we encourage such workshops to include many frequent and diverse field trips and visits to RDIs so that learning includes as much experience and novelty as possible.

Also, instructor(s) should mix as many methods of instruction and exercise as possible; in order to maintain the interest of participants. Each of the exercises in the **Manual** may be adapted to a variety of techniques. It is up to the instructor(s) and participants to select those which are more useful and instructional.

Above all, this learning experience should be enjoyable. It can be made so by adapting the **Manual** to the needs and learning habits of the R&D managers who look to it for guidance. The **Manual** was designed with flexibility in mind. We encourage R&D managers and instructor(s), alike, to adapt it to their own needs and interests.

Two-Column Format: If you thumbed through the **Manual,** you probably noticed that it is produced in a two-column format.

The left column provides the text for the programme of study. For an instructor, it serves as the basis for lecture and discussion material.

For the R&D manager, it serves as the basic content for self-instruction or workshop preparation. The right column, on the other hand, is where we relax a little bit and introduce some of the fun and flexibility in use of the **Manual.**

Your Notes: Here you can add your own thoughts, comments, questions and notes as you read, listen to a lecture or participate in a discussion. You are encouraged to write right on the page. That way your thoughts remain with the textual material; and the combination becomes a more powerful learning tool.

Our Notes: But you will also find our notes here. They are in many forms. Some of them are questions which we would like to ask you to answer. They serve the purpose of providing a review of the textual material. If you can answer all these questions satisfactorily, then you probably have a good grasp of the material in the Chapter.

These questions are also helpful to the instructor(s) who can use them as a basis for classroom discussion; they can even be used to develop small group, team, exercises.

Each question is located close to the textual paragraphs (in the left column) which provides a basis for answering them. So if you have difficulty with them, you will have no trouble finding out where to go for help.

"Cases": The right column also contains descriptions of real RDI experiences which characterize what we are talking about in the text. We call them **"cases"** because they represent real situations. However, we use the word advisedly because they are really too short and underdeveloped to represent real cases in the strict sense of the word. They are included to add a flavour of reality to what we are discussing in the text.

Emphases: We also use the right column to emphasize key points. Sometimes we do it by making a comment. Other times we may do it with a simple diagram. But do pay attention; those notes in the right column — our notes and your notes — are like a traffic signal. They direct your travel through this course of instruction; and they regulate your learning.

Definitions: As with any new material, you will undoubtedly run into new words. Many of them are important for you to learn because they are part of the special language of R&D management. We try to emphasize them in a couple of ways.

The second topic of each Chapter in the **Manual** presents new definitions. But, we also print these words in boldface type the first time they appear in the text. That should draw your attention to them. Then, their definitions are usually underscored. Finally, we will include a glossary of words which will also help you adjust to the language.

Boldface Text: We also use the boldface text to emphasize key ideas throughout this **Manual.** If nothing else, we sincerely hope that all participants leave this course of instruction with renewed appreciation for the role of R&D in national development.

Above all else, we want all participants to re-orient all their management ideas, and practices, to actually achieve useful R&D results "what we are calling productive R&D". Therefore, we use the boldface type to emphasize summary statements about productive R&D.

Citations: Occasionally, the text may also bear a person's name in parentheses. This is a bibliographical citation. It means that the idea immediately preceding the citation came from another author. You may discover the original source of the idea in the annotated **BIBLIOGRAPHY** which appears at the end of the **Manual.**

The bibliography is comprehensive. It contains far more sources than were cited in the text.

You will also find citations at the end of each Chapter. These are the sources which had the most direct impact on the development of material contained in the respective Chapters.

Summary: Good luck and have fun! Together we are embarked on a noble venture, i.e. to enhance development for nations of the world through the carefully managed application of the principles of science and investigation. There is no more noble cause — and no more challenging approach to it.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER I

PLANNING AS A MANAGEMENT FUNCTION

Planning as a Management Function

Training Objectives

By the end of this chapter the participants should be able to:

1. State why planning is a critical management function.
2. Explain the context in which planning takes place.
3. Describe how the other management functions relate to planning.
4. Explain how these management functions relate to each other.
5. Describe the role of leadership style in management.
6. Distinguish between strategic, managerial and operational aspects of planning.

Planning as a Management Function

Contents

All of this material can be covered in one session. Prior reading is recommended.

CHAPTER I

PLANNING AS A MANAGEMENT FUNCTION

Introduction

1.111 In an organizational setting, a manager has many duties to perform. These duties have been classified into what are known as management functions. While there are many of these functions, it has been observed that planning is by far the most important function of a manager. A manager, whether he is managing a large public institution or a small organization of two or three persons needs to plan his time, his resources and his courses of action so that they are directed towards the attainment of some purpose.

What are the other functions of a manager?
List them:

____
____
____
____
____
____

Definition

1.112 **Planning** has been broadly defined as "the process of preparing for change and coping with uncertainty by formulating future courses of action". It involves a conscious effort of thinking about the future and of mapping out a series of strategies intended to make the planned outcome a reality. Planning has to do with limited resources and an uncertain environment. Even if resources were unlimited (which they rarely are), the future environment can never be known with certainty. An event in one place may cause a whole series of events elsewhere which may make the original intention not capable of realization. We have therefore to plan in order to anticipate those future

Provide your own definition of planning:

____
____
____
____

Name some "unlimited" resources:

____
____

events and to be ready with contingent courses of action to prepare us for each of those events.

1.113 Planning can be for a short period of time — like a few hours — or for a long time span which might run to, say, five years. For some organizations, a long range plan can be for ten years or more, depending on the complexity of that organization and its needs. Long range plans can be broken up into shorter duration plans so as to address specific problems associated with those shorter periods.

It is not possible to have a contingent plan for every outcome. Why is this the case?

____

____

____

Such plans are also known as strategic plans. Examine your own organization's plans and see if they are easily classifiable into various categories.

Functions of Planning

1.211 As has been stated, planning is carried out so as to enable the manager to anticipate the future. This is indeed a primary reason for planning but individual managers may see the planning function somewhat differently. For instance, when two experienced managers of large companies were asked the simple question: "Why plan?", this is how they replied:

Table 1.1. Why Plan?

Douglas Gerhman
Exxon Corporation

Why plan?

- Increases chances of success by focusing on results, not activities.
- Forces analytical thinking and evaluation of alternatives, thus improving decisions.
- Establishes a framework for decision making consistent with top management's objectives.
- Orients people to action, instead of reaction.
- Modifies style from day-to-day managing to future-focused managing.
- Helps avoid crisis management and provides decision-making flexibility.
- Provides a basis for measuring organizational and individual performance.
- Increases employee involvement and improves communication.

Merrit Kastens
Union Carbide

So why do you plan? Not to predict the future — because you're kidding yourself into a lot of predetermined actions because that is likely to be as disastrous as persisting in what you have been doing in the past. You plan in order to find out what the hell is going on and because it gives you the only chance of getting a grip on the future success of the enterprise. You plan because you are bruised and bloody from being knocked around by events that you do not understand and from finding yourself in corners when it is too late to do anything about getting out of them. You plan because you are tired of managing from crisis to crisis, of constantly putting out fires — or more likely stumbling around in the hot ashes. You plan, not because it is fun. It is not, but it can be exciting. You plan, not because it is a new management fad. After thirty years, it is well beyond that stage. You plan, because it is your best chance for survival in a world that is changing as fast as ours is. Furthermore, I will clue you: if you are going to be a manager, it is a lot more pleasant when you know what you are doing.

SOURCE: Robert Kreitner, **Management**, 2nd Edition, Houghton Miflin Company, Boston, 1983.

In the space below, give your own view of why planning is necessary.

1.212 From an evaluation of these two views of the planning function, one may be able to summarize the functions of planning as follows:

1. To allow a clear specification of what the organization is expected to achieve.
2. To allow for the determination of the quantities of various resources required to achieve organizational objectives.
3. To allocate those resources in the most logical and productive manner.
4. To anticipate problem areas and to determine now those problems can be solved.
5. To allow for the determination of whether the organizational objectives have been achieved.
6. To make decision-making a more organized process.
7. To enable managers to understand what is going on in their organization.

8. To make the rewarding of superior performers a more rational process.

What is your opinion of this last one?

1.213 There may be other minor aspects of the planning functions but, one way or the other, they probably revolve around the eight which have been identified above.

You may wish to add others which you consider important.

The Basis of Planning

1.311 The process of planning can be seen as a mental activity which starts with an attempt at understanding the general mandate of the organization and ending with a detailed document showing **what** must be done and **how** it will be done. At the general level, one is dealing with **concepts** while at the operational level, one is dealing with relatively unambiguous instructions.

What is your organization's operating environment?

1.312 In order to plan effectively, it will be necessary to make some assumptions about the environment within which the organization will effect the attainment of the goals of the organization. In attempting to direct attention on key issues, Kreitner has identified some six Ps of the planning process and it is useful to look at these.

1.313 Kreitner's six Ps of the planning process are:

- **Premises**
- **Purpose**
- **Philosophy**
- **Priorities**
- **Policies**
- **Plans**

1.314 **Premises** are the basic assumptions about how the environment of the organization looks like. The environment could be a specific part of a country, a country as a whole, a group of countries or even the whole world. Another way of looking at the environment is to ask about who else is in the same area of operations as yourself, what their strengths and weaknesses are in comparison with yours, what opportunities exist and, perhaps, how they could be exploited. It is in an attempt to understand **where** the organization stands in

In business parlance these are referred to as competition. In an R&D, they may not have the same connotation.

relation to other participants who might affect it **directly** or **indirectly** within the planning horizon.

1.315 **Purpose** refers to the mission of the organization. What does it exist to do? Why was it set up in the first place? What is expected of it by society at large and by the founders? It is a conscious effort to state the mandate of the institution.

1.316 **Philosophy** here is meant to indicate how the organization is intended to be run once the purpose has been understood. Since it is possible to achieve a given objective in several ways, there may be some ways which are either unacceptable on moral or social grounds. The philosophical stance taken by the organization determines which of these options is acceptable.

1.317 For instance, in an institution visited in the course of fieldwork for this manual, the researchers were told of the case of a senior research scientist who wanted to use a fairly sophisticated piece of equipment in tsetse fly research. The equipment was also quite expensive and its purchase would have necessitated either suspension or termination of other research projects within the tsetse research programme. Since the RDI's philosophy was that the use of sophisticated equipment was less preferable to the use of simpler equipment — even if it took much longer to achieve the desired research goal — there was no question of acquiring the more sophisticated equipment. This was **regardless of whether the funds were there or not.** In the case above, the researcher resigned when the director stood his ground.

1.318 **Priority** areas are those which have been determined to rank higher than other areas. There is a need for the organization to look at those things that it can do and arrange them in some order of importance. It is unlikely that this can be done properly unless the purpose for which the organization was set up is specified and the philosophical issues are resolved. Ideally, a formal ranking method for projects is preferable to the less objective ones.

What is your RDI's mission?

____

____

____

____

In certain medical research institutions, before any research project is approved for funding, it must have been cleared by the ethical committee of the RDI. Do you know of similar cases?

____

____

____

If you have come across similar instances in your career, you may list them for discussion.

Distinguish between formal and informal priority ranking methods.

____

____

____

____

1.319 Once the priorities have been determined, **policies** have to be specified to act as general guidelines or constraints in the execution of the organization's mandate. Sometimes, it may be difficult to tell the difference between a policy and a philosophy. A policy can be stated in fairly direct terms whereas a philosophy tends to be quite general and rather ambiguous.

1.320 Policies may result in **plans**. A plan is quite specific in showing what will be done in a given period of time. As was indicated earlier, a plan can be long term or short term; it can be broad or it can be quite detailed; it can be at the strategic level or it can be at the operational level; and it can be cast in monetary terms or in non-monetary terms.

Types of Plans

1.411 **A strategic plan** may be conceived of as a broad, ever-changing programme of organizational emphasis and resource deployment which responds to the changes in the environment within which the organization is operating. It is thus not a detailed, idealized plan which has to be rigorously enforced; it must be flexible enough to allow for adaptation as things change. A strategic plan must address itself to those alternatives which are not only feasible but are also practical.

1.412 **An operational plan** or operating plan, on the other hand, is the translation, in present-day terms, of the corporate strategy so as to solve problems of an operating nature. As things must be produced, people employed, resources deployed throughout the organization, it follows that this must be done systematically and not randomly. An operating plan ensures that this is done satisfactorily.

Consider the simple case of someone who wishes to build a house. He must start with an idealized version of what kind of house he wishes to have, then think about the more practical aspects like site, finances, then to materials, labour and so on.

1.413 A **budget** is a specific case of an operating plan which is expressed in financial terms. It specifies the actual quantities of money which it is intended to spend in order to achieve a particular objective. It may also show the amount of money expected to be received from the sale, say of a particular commodity. A special case of a budget is the **cash budget** which summarizes, in as much detail as is required, the amount of cash expected to flow into and the amount expected to flow out of the organization.

Other Functions of Management

1.511 We have concentrated so far on planning as a managerial function. While planning is important, it is by no means the only one. Management analysts and educators (for instance, Koontz & O'Donnell, Peter Drucker) have identified what has come to be known as the basic functions of management. These functions will generally be there whether we are dealing with small or large organizations; it is only the degree of complexity which changes. We now turn to these briefly.

Before you read further, think of other management functions and list them down below:

____
____
____
____
____
____
____

Then read on.

1.512 **Organizing** is a management function which is directly related to planning. Organizing means marshalling all resources available to a given organization and directing them in a **purposive** manner. Without planning, it is unlikely that there can be anything to organize. In classical management, organizing is viewed as "the structuring of a coordinated system of authority relationships and task responsibilities". This is achieved by "spelling out who does what and who reports to whom ... in an attempt to translate strategy into an on-going productive operation". Whichever way we look at it, it is quite clear that someone will have to be assigned specific responsibilities in a given organization since no one person can be charged with the responsibility of doing everything. In R&D institutions, this is perhaps even more critical since most scientists would rather be concerned with actual research than the tedious job of procuring materials, checking on prices, etc. These functions can be done by someone else and it is the responsibility of the organizing manager to determine who these people are and the specific tasks attached to each one — all in an attempt to satisfy the objectives of the RDI.

Just what does this mean in plain terms?

____
____
____
____
____

***Delegation** is an important art in management and RDIs are no exception. Failure to delegate can be a serious blow to RDI effectiveness.*

1.513 **Staffing** simply means filling jobs with appropriately skilled people. Someone has to identify what the needs of an organization are with respect to the tasks to be performed. Once this is done, persons with the necessary skills and qualities must be recruited. If they are not immediately available, a training programme for them has to be set up. It follows, therefore, that **staffing** and **training** are closely interrelated and complementary aspects of the same function.

1.514 A personnel manager or officer will usually be available to hire people who are required in an organization or to fire those whose services are no longer needed. He, however, cannot do this in isolation — someone has to define the qualifications needed and the experience required for a given task. As the organization grows the staffing needs also grow and it is important to keep up with the needs of the growing organization. Anticipating future staffing needs is again an issue we cannot afford to overlook in the planning process.

Who does the staffing in your RDI? By what title is he/she known?

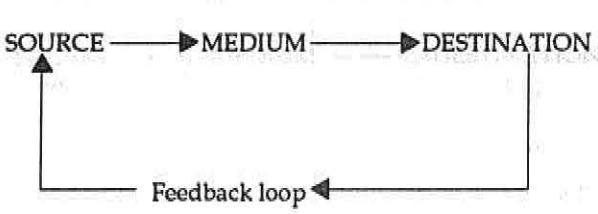
1.515 In an RDI, the staffing position is usually precarious and this will be considered in due course in greater detail so that we can see how to enhance the RDI's productivity by not only staffing with right people but also anticipating the critical needs for various projects in an RDI.

1.516a **Communicating** means making sure that individuals within an organization not only understand their jobs but also their respective positions/roles in a given situation. Management must be able to give clear and unambiguous instructions regarding operations and duties if conflict and wasteful corrections are to be avoided in the future.

Scientists are by nature precise people. Yet there are many instances when it is practically impossible for laymen to understand what the scientist considers elementary instructions. Has this type of situation manifested itself in your RDI? If so, give examples:

1.516b Communication is a topic in a scientific area which touches upon **signal theory**.

There are three components in this scenario:



1.516c The **source** gives out the **message**. This message is transmitted through a **medium** which may be oral, written or electronic. It is finally received by a receiver.

1.516d In the course of the transmission something could go wrong. For instance, the message may be distorted by successive generations of transmitters and this distortion may be so severe that at the end the final message bears no relationship to the original message. Alternatively, the sender may be so poor at communicating that the message is either missed altogether or it is misunderstood by the receiver. The mark of a good communication system is one whereby minimal message disturbance occurs between the sender and the receiver and where the basic content and tenor of the message is received clearly and understood unequivocally. More of this can be read in any good text on communication theory.

1.516e Good communications are of paramount importance in an RDI, particularly where important scientific work requiring precision is being carried out. We shall have more to say about this at a later stage.

1.517a **Motivating** and **leading** are two other functions which are closely interrelated. Motivating simply means getting individuals to not only perform at their best but also to do so in a manner **that is consistent with organizational goals**. A well motivated group of workers is an asset to any organization and they therefore do that which is productive to the organization.

1.517b Motivation can take many forms. It may derive from **personal identification** with the organization's goals — this can be true of many RDIs. In this case, the individual sees his own success in terms of the organization's success and vice versa. Alternatively, the individual may be motivated by someone in authority — like a superior whom he admires greatly and will sacrifice personal ideals for the sake of that individual. It is a form of loyalty which is pivoted on the other individual in his organizational role although it may be difficult in practice to distinguish between the two roles.

Experiment in Communication

A little experiment which can be carried out quite easily is to use participants in a seminar. To start, write down a one sentence message of about six to eight words. Give it to the first person in the seminar and ask him to tell it to the next person who tells the next person to him and so on until it gets to the last person. Ask that person to write down what he has heard. Write both messages on a board for all to see!

In an RDI visited in the course of the fieldwork for this manual, one or two scientists indicated that the only reason they stayed on in that RDI was due to the "high regard" they had for the director, an eminent scientist. Is this type of loyalty good or bad for the organization?

1.517c Motivation could also be **pecuniary** i.e., financial rewards of an acceptable level are offered and this keeps the individual within the organization. The danger with this is that if another organization were to offer higher financial reward, the person would easily be tempted to take the new offer. It is important therefore to understand the employees and to know what motivates them.

Our experience in the region was that most scientists did not rank pecuniary rewards very highly.

1.518a **Leadership** is closely intertwined with motivation. A good leader knows how to make his subordinates "happy" in the work sense. He will lead them on to actualize their capabilities. He may do this by using various motivational or power tools. He could, instead of the motivational tools suggested above, use **power** and **force** to demand obedience, loyalty and performance. This he does by setting up targets/goals which must be achieved under pain of loss of job, for instance, or threats and intimidation.

How does your RDI director motivate you? How do you in turn motivate your subordinates? Do you use the "carrot" or "the stick" or a combination of these?

1.518b **The style of leadership** is important because it determines how the organization holds itself together. There are many articles and books which have been written on power and influence but they are beyond our interest in this manual. In these books, however, three dominant leadership styles have emerged over the years of research and we now briefly look at these.

Table 1.2. The Three Classic Styles of Leadership

	Authoritarian style	Democratic style	Laissez-faire style
Nature	Leader retains all authority and responsibility	Leader delegates a great deal of authority while retaining ultimate responsibility	Leader denies responsibility and abdicates authority to group
	Leader assigns people to clearly defined tasks	Work is divided and assigned on the basis of participatory decision making	Group members are told to work things out themselves and do the best they can
	Primarily a downward flow of communication	Active two-way flow of upward and downward communication	Primarily a horizontal communication among peers
Primary strength	Stresses prompt, orderly, and predictable performance	Enhances personal commitment through participation	Permits self-starters to do things as they see fit without leader interference
Primary weakness	Approach tends to stifle individual initiative	Democratic process is time consuming	Group may drift aimlessly in the absence of direction from leader

Source: Robert Kreitner: **Management**, 2nd Edition, Houghton Miflin Company, Boston, 1983.

1.518c Obviously, these are what are known as ideal types and, in real life, a person may not fit quite neatly into any of these classifications. A person may exhibit traits of several of these categories at different points in time or in different situations. Proper leadership, in our view, implies getting to know which approach to use in given circumstances — i.e. what is known as a contingency approach to leadership.

1.518d A proper understanding of motivation and leadership is important for the proper management of RDIs. These are institutions where scientific personnel are used to doing basically creative or original work and the question will arise regarding how one can best take advantage of the natural abilities of the research scientists to enhance the productivity of the RDI. What style of leadership is, for instance, best suited to a pure research institute? How does the director organize such people to ensure that he does not stifle creativity by being too formal? Do scientists expect rewards to motivate them and what kind of rewards should these be?

Try answering these questions by relating them to your own RDI.

1.519a **Controlling** is another management function with probably negative connotations. Controlling implies ensuring that a given path is followed consistently and purposively. In other words, proper control implies a good understanding of organizational objectives, knowledge about the means and finally knowledge about how to do what has to be done and how to know when proper corrective action has to be applied.

How do you view control? Negatively or positively?

____

____

1.519b In classical management, controlling is defined as "the process of taking the necessary corrective action to ensure that organizational objectives are achieved as effectively and efficiently as possible". Objectives are yardsticks against which actual performance can be evaluated. Without clearly defined objectives, it is virtually impossible to have the elements of a good control mechanism. In assessing performance, concern will be with determining actual performance and comparing it with anticipated or expected performance. A deviation from this level

Note the two key issues!

Better than expected performance may imply low standards in the first place. In this case, the standards should be re-evaluated.

of performance (either way) should draw attention to the need for corrective action.

1.519c It should be apparent therefore that a good control system will require:

- **Goals, objectives or plans (in detail)**
- **Measure of performance (actual)**
- **A system of comparison**

1.519d Control can be divided into two levels: management control and operational control. Management control is concerned with achieving overall organizational goals and it is therefore a concern that all parties in the organization are seen to be not only working together but are in actual fact working together towards that goal. A senior manager should be in a position to determine the necessary and unavoidable trade-offs in achieving this overriding goal.

1.520a Operational control, on the other hand is, as its name implies, concerned with operations. Production schedules must be attained, work must be programmed, proper staff must be hired, materials of the right quantities must be procured, etc. In short, the wheels of the organization must be kept turning smoothly and at the right speed.

1.520b We shall have a lot more to say about control and the related aspects of monitoring when we deal with project monitoring and evaluation as specialized topics.

Decision-Making

1.521 While not specifically mentioned in classical management, an additional aspect of management is decision making. Managers have to make all sorts of decisions in the performance of their duties and it is this critical role that distinguishes managers from other operatives. In the course of planning, coordinating, staffing etc., decisions have to be made at all times and proper management requires a knowledge of the type of decisions that a given manager can make and that which he can refer to a higher level. Indeed, one may safely say that decision-making is what management is all about.

1.522 In an RDI, all these management functions exist and it is only by orientation to the special needs of RDI that management differs from the general corporate management about which so much has been written.

Summary

1.523 In this chapter, we have attempted to place planning as a managerial function in its proper perspective vis-a-vis other supporting and complementary management functions. Management was seen as encompassing the following functions:

- **Planning**
- **Organizing**
- **Staffing**
- **Communicating**
- **Motivating and Leading**
- **Controlling**

1.712 All these functions are important in achieving organizational goals . A proper understanding of each one of them will help the RDI manager have a clear idea of how he can apply himself in the quest for higher productivlty in his R&D institute.

Bibliography

Ackoff, Russel L., **A Concept of Corporate Planning**, New York: Wiley Inter-Science, 1970.

Argenti, John, **Corporate Planning: a Practical Guide**, London: Allan & Unwin, 1968.

Arnon, Itzhak, **The Planning and Programming of Agricultural Research**, Food and Agricultural Organisation of the United Nations, 1975.

Brickner, U.H. and Cope, D.M., **The Planning Process**, Cambridge: Mass Winthrop, 1977.

Butler, Arthur G., "Project Management: A Study in Organizational Conflict", **Academy of Management Journal**, March 1973.

Collier, James R., **Effective Long Range Business Planning**, Englewood Cliffs N.J.: Prentice-Hall, 1968.

Emery, James C., **Organisational Planning and Control Systems: Theory and Technology**, London: Macmillan, 1969.

Kahalas, H., "A Look at Major Planning Methods: Development Implementation, Strengths and Limitations", **Long Range Planning**, August 1978.

Kreitner, R., **Management**, Houghton Miflin & Company, Boston, 1983.

Mize, J.H., White, C.R. and Brooks, G.H. **Operations Planning and Control**, Englewood Cliffs, N.J.: Prentice-Hall, 1971.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER II

PROJECT PLANNING FOR RDIs

PROJECT PLANNING FOR RDIs

Training Objectives

By the end of this chapter, the participants will be able to:

1. Define a project and project planning.
2. State the role of priorities in project planning.
3. Explain why project planning must precede all other steps.
4. Distinguish between programmes and projects.
5. Explain the need for resource allocation to projects within the programmes.
6. Prepare a project plan using a variety of tools.
7. Distinguish between a good project plan and a deficient one.

Project Planning for RDIs

Contents

This material can be covered in two sessions.

CHAPTER II

PROJECT PLANNING FOR RDIs

Introduction

2.111 In the previous chapter, no special emphasis was given to planning in as far as RDIs are concerned. In this and subsequent chapters, our primary concern will be with planning for RDIs and specifically for projects in which a researcher is expected to get involved.

2.112 **Project planning** is viewed in this discussion as a part of the wider issue of planning in general. In the present case, it is assumed that the research scientist has already been made aware of the general framework within which his RDI operates and is further aware of that RDI's mandate in national development. For those who need a refresher in this area, we suggest a reading of Chapter I of the **Manual** on "Strategic and Project Planning and Budgeting". Indeed, a reading of the whole manual will enable the reader to better appreciate project planning, monitoring and evaluation.

What is the mandate of your own RDI?

____

____

____

Research Priorities

2.211 Research priorities are normally established for each institution by its council or some other such body of the RDI. These research priorities go through a series of steps before they are finally agreed upon. An RDI may, for instance, be concerned with animal research. A

Who establishes priorities in your RDI?
What steps are taken before they are agreed upon?

general policy statement may be made such as that "it is the objective of this RDI to undertake such research work as is necessary to control animal diseases and to increase animal productivity".

2.212 A general statement like this can be viewed as the mandate of the RDI. By itself, it, of course, is not sufficient guide to a researcher who needs to have far more specific information in order to achieve his part of institutional mandate. Unanswered in a statement like this are questions such as:

- **What kind of animals is the RDI concerned about? Cattle, sheep, goats, game animals, etc?**
- **What are the common diseases of such animals? Worldwide? for this country?**
- **What is the impact on such diseases on animal productivity?**
- **What is meant by productivity in the first place?**
- **Is there a time horizon for the research effort?**

Ask similar questions for your RDI.

2.213 When we start asking such questions, we are getting into the area of operations. Someone, therefore, has to get down to the business of breaking down the general policy mandate into something workable or executable.

Research Programmes

2.311 One way of doing this is to get down to specifying various research programmes within the general area of animal research. A research programme is defined as a broad collection of resource consuming activities which have a common basis and which can be subdivided into smaller, specific projects. For instance, in one case encountered involving animal research, the following four major research programmes had been identified:

- **Animal diseases research**
- **Livestock production research**

- **Tsetse and trypanosomiasis research**
- **Pasture research**

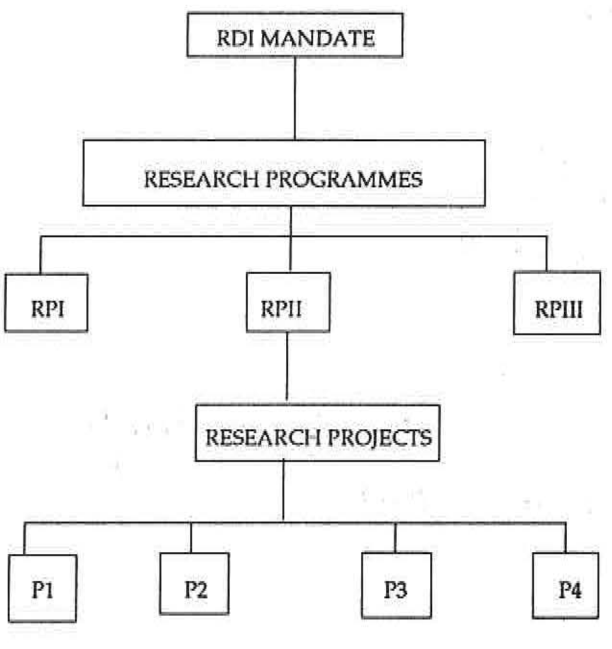
2.312 Each of the research programmes has a specific target and, within each, one can see the possibility of further subdivision into specific areas of research or projects.

2.313 In the case referred to here, we found that for each programme, there was a considerable amount of detail regarding what has to be done within that programme. The individual research targets within a programme are referred to as projects and it is these latter which form the focus of our attention. In some cases a research programme may be difficult to distinguish from a project and in one organization a project may be as large as a programme in another organization.

How easy is it to distinguish programmes from projects in your RDI? Give examples:

2.314 The relationship between Programmes and Projects could be visualized in schematic form as in Figure 2.1 below.

Figure 2.1



On a separate page prepare a schedule of research programmes and research projects in your own RDI.

2.315 As can be deduced from looking at this diagram, every research project derives its existence from the institutional mandate via programmes. In certain types of institutes, there may be no identifiable programmes, and in such a case, the project may arise directly from the top but accountability for the results goes up from the bottom. It is vital that this relationship be kept in mind at all times.

Programme Formulation

2.411a A question arises regarding the formulation of research programmes. Who, for instance, develops these research programmes? How do they do it? What steps are followed in establishing these programmes?

Answer these questions for your RDI.

2.411b In many of the organizations visited in the course of fieldwork for this manual, it was found that there were different approaches to the process of setting up programmes. Two cases are given below. In one case, the director of the RDI delineated these programmes after a study of the policy statements that gave the RDI its existence. After this was done and a paper prepared for the governing body, the paper was presented to this body for consideration and approval. This approach appears to be suitable for new and small RDIs where the director might be working pretty much on his own or with a skeleton staff.

2.412 In another case, the procedure was to call in all the senior staff for a planning meeting. Such a meeting would be held in a hotel or a conference centre away from the usual office distractions. The agenda of such a meeting was to:

- **Interpret institutional mandate**
- **Derive research programmes**
- **Suggest criteria for setting up projects**
- **In some cases, identify priority projects within programmes**

Which of these two approaches closely approximates your own situation?

2.413 The procedure in the second case differs from the first one in that there is a more democratic approach to planning. All the parties involved will have participated in this exercise and are therefore more likely to identify themselves with the RDI's aspirations. Once the programmes and tentative priorities are identified, the next step is to present these to the governing body for formal approval. Unless there has been a serious misunderstanding of the mandate, the governing body would not be expected to turn these down. An alternative procedure which can be used to increase the probability of approval is to involve key members of the governing body, especially those who are more scientifically oriented and who have a clear vision of what the RDI is expected to do.

Why do you think that the governing body would not turn them down?

Is this a wise thing to do? Why or why not?

2.414 Whatever method is used to formulate the programme, one may wish to ask the following questions:

- **Do we have a clear mandate in our RDI?**
- **Where is it to be found?**
- **Do we have separate programmes in our RDI? Which are they?**
- **Are these programmes distinct or do they cut across programme lines?**
- **How were these programmes established? When were they established? Are they still valid?**
- **Are the programmes balanced in terms of resources allocated to them?**
- **Do the staff in my RDI know about these programmes? If not, how do they proceed in their work?**

2.415 Questions such as these help in focusing your mind on the programme structure of your RDI. One may also wish to consider whether the director is of the authoritarian, the laissez-faire or of the democratic type. At the same time, questions should be asked regarding how the leadership style of the director is likely to support or impede programme identification and implementation.

2.416 It should be noted at this stage that we are not saying that a given leadership style is good or bad. What we are saying is that the style is likely to interact with the RDI's goals and mission and, depending on the situation at hand, may have desirable or less desirable results. It has been found out, for instance, that an authoritarian or paternalistic style is suitable where the staff is lacking in vision and initiative or is composed of relatively young people. They look upon the leader to provide this leadership and may be visibly unhappy if they are asked to participate. On the other hand, a highly motivated and creative group of scientists will feel stifled if they are subjected to such an authoritarian style. They expect to be involved and must somehow be involved if there is to be progress and productivity.

Are you aware of any situation such as this?
Give details.

Allocation of Resources to Programmes

2.511 Once programmes have been clearly identified and approved, one more step is still necessary at the policy level. This is what can be called global resource allocation.

2.512 In practical terms, this means that there must be some indication of the **relative importance of each of the programmes within the RDI.** In the previous illustration, it might have been determined in terms of priority, that the control of animal diseases was the most important. A follow-up question then becomes:

- **What proportion of the total RDI resources should be allocated to this programme?**

It is not enough in our view, to couch importance in some general terms which are safe but relatively ineffective as a guide to resource allocation. Someone has to take the responsibility of making it explicit. This is the responsibility of the governing body with the director's guidance.

2.513 At a practical level, the allocation might be done in the following manner:

- **Allocate each programme an equal part of the total**

- **Determine relative ranking in order of some specific criterion (criteria)**
- **Determine allocation weighting system**
- **Determine minimum requirements for each programme's survival**
- **Allocate balance above minimum on the suggested weights**
- **Determine final allocation for each programme.**

Illustration

2.514a The following is an illustration of how this scheme can be applied. We start with four programmes A, B, C and D. Each is allocated 25% of the total in the absence of any other fair rule.

2.514b The order of priority is determined (after due consultation with senior staff and/or governing body) to be as follows:

A	1
B	2
C	3
D	4

This is just an ordinal scale in which the difference between any two levels is not necessarily the same.

2.514c Next is the attempt at determining the perceived or real importance of the programmes. Since the above ranking is just a numeric rank which does not show the degree of importance, we might assign the four programmes a total of 10 rank points and distribute these points as follows:

	Rank	**Points**
A	1	5
B	2	3
C	3	1
D	4	1

2.514d In this part what we are saying is that while Programme A is considered to be the leading programme for the RDI, that lead has been allocated an importance that is five times that of Programme D which is fourth. Programmes C and D are considered to be "equal" in resource needs although using some other criteria, C is considered to be more deserving than D. Both C and D combined need less resources than programme B. The purpose of this allocation is to put more emphasis where such emphasis is required.

2.514e The next step is to determine the minimum resources required to make each programme a "continuing" programme. Essentially what this means is that any continuing or active programme must be assigned a minimum amount of resources to cover such things as overhead costs and other unavoidable costs. It may, for instance, be felt that the loss of a particularly useful scientist in a specific area would be so damaging to the future of the RDI that it is better to pay that individual his full salary and deploy him in relatively easy tasks while waiting for the programme to be fully operational.

This situation is analogous to one observed in movie business. If a new movie is to be made and a particular film star has been identified, he could very well be commissioned and be paid to go on holiday while the operational aspects of the filming are being worked out.

2.514f The minimum allocation for each programme might be specified in terms of the total resources. Thus,

	Basic Resources
A	12%
B	5
C	5
D	3
	25

This allocation commits 25% of total resources and leaves us 75% to share out among the four programmes.

2.514g We can now summarize the position as follows:

Programme	Rank	Weight	Minimum	Balance	Total
A	1	5	12%	37.5%	49.5%
B	2	3	5	22.5	27.5
C	3	1	5	7.5	12.5
D	4	1	3	7.5	12.5
Totals	10	10	25	75.0	100.0

2.514h The amount to be allocated to each programme is calculated as follows

Allocation	A	=	5/10 x 75%	=	37.5%
	B	=	3/10 x 75	=	22.5
	C	=	1/10 x 75	=	7.5
	D	=	1/10 x 75	=	7.5
Total points					75.0

2.514i The final allocation is merely an addition of the minimum (quota) and the allocation of the balance.

2.514j One could use other allocation methods — e.g. reversing the rankings to give the amounts due to each programme, thus:

Programme	Rank	Reversed	Proportion
A	1	4	40%
B	2	3	30
C	3	2	20
D	4	1	10
			100

2.514k Whatever allocation method one uses such a method should act as a fair guide to resource allocation within a given RDI. The most important points to note are that the process:

- **Must be consciously done**
- **Must be equitable**

Is there a well defined resource allocation method in your RDI? If yes, give in outline form the procedures used.

- **Must reflect the RDI's intentions for achieving its research goals**

2.5141 As in other instances of management activity, a review of the formula used should be made whenever it has become evident that the formula is no longer valid. Indeed, it should be apparent that a review of programme structures and relationships is a necessary aspect of the planning process.

Formulation of New Programmes

2.611 As an RDI grows, it becomes inevitable that new programmes have to be created. These may come about through new projects which somehow cannot fit in with existing programmes of research. Such projects might have been the result of a scientist getting involved in an area which was slightly outside the established programmes. In the course of doing this, a whole new area of research may be opened up and its importance may be such that a completely new programme has to be set up.

Can you list some projects in your RDI which came about this way?

2.612 On the other hand, the institutional mandate may be expanded at the policy level or due to a government directive. For instance, in many agricultural research programmes, traditional African crops like yams, cassava, millet, etc. might not have been of special interest to the then generation of researchers (as was the case during the colonial period for many African countries). After independence, these crops acquired new importance from a research point of view. Or, due to changing weather patterns or pests, a crop that was not scientifically interesting may become a focus of research interest.

2.613 Whatever the source, it is important that new programmes should be given early recognition particularly from a resource allocation point of view. As can be expected, there will be initial difficulties as acceptance of the new programmes is being considered. Human nature is such that resistance to any new ideas will always be there whether it is from the scientific community or from funding agencies such as government departments.

Consider some of the practical difficulties you may have seen when trying to set up new projects or programmes.

2.614 Just as new programmes can be set up, several existing programmes which are relatively small can be merged into one. This is a consolidation process and implies a sort of "empire building". What happens in this case is that an ambitious scientist sees the opportunity of getting more resources under his control and does this by suggesting that two programmes could be merged, ostensibly to make them "more manageable", or to get certain benefits from "economies of scale". The two programmes then finally get merged and, from a practical point of view, that person becomes the natural head of the new expanded programme.

Are such cases common or rare in your RDI?

Financing of New Programmes

2.711 A question which arises from a planning point of view is: How does one get a new research programme to be funded? A good understanding of the process to be followed can be taken from the fertile field of budgeting for public institutions.

2.712 In a book entitled **Politics of Budgetary Control**, Wildafsky has suggested some strategies for creating new programme or budget heads. One of these is to ask for a **token amount**. This should be quite small in relation to the total (say no more than one per cent or even the proverbial one pound or one dollar). Once this little amount has been given, usually on what is stated to be an experimental basis, all that one needs to do is to keep on adding a little bit more each successive period and since the initial amount **was** given, it becomes much harder for subsequent increments **not** to be given. What therefore started off as a tiny programme grows to compete with existing programmes and, depending on the strength of the "sponsor", might even become a major programme.

Trace backwards a specific programme or project in your RDI in an attempt to discover how it has evolved.

2.713 Where no new programmes are acceptable, a second alternative is to request for permission to "borrow" limited funds from other ongoing projects in order to support that new programme. A clear statement will usually accompany such a request indicating that the borrowing of such funds will not interfere with ongoing work and that further requests of funding for those projects will not be made. Of course, this is untrue, but it may not matter at this stage. The effect of this strategy is to allow an internal transfer or virement, in government terminology — which in due course becomes a permanent feature. The programme then will have been developed internally to such an extent that it becomes so important that the sponsors can ask for independent recognition as a separate item. This will not be difficult to achieve since it will then be easy to demonstrate that the project is useful in its own right and has to be separately recognized and funded.

This is an incremental approach to funding.

2.714 Another practical approach is to create a case for the splitting up of an ongoing programme in order to cater for differences which can only be dealt with satisfactorily only if certain activities of the programme are catered for separately. For instance, in the earlier example of the four programmes in the animal research organization, one of the programmes was stated to be "Animal Diseases Research Programme". This is necessarily a wide programme which may have a good number of projects. After a few years, it may become evident that Tick Borne Diseases comprise a significant proportion of cattle diseases. A proposal could be made and be easily justified for the setting up of a special programme on tick borne cattle diseases. All the other diseases would then be left in the basic programme leaving those researchers who are interested in tick borne diseases to move with the new programme.

This is a common and effective way of getting new programmes.

2.715 Another interesting approach is to use an external donor to support a local project. Since no local financial resources are used and since donor support is usually encouraged, it becomes a matter of time before such a project develops into a full-fledged programme which eventually becomes a national programme due to its importance. Ultimate funding by the government then becomes a virtually foregone conclusion.

Can you give cases which you have experienced which are of this type?

Project Planning

2.811 Now that we have covered in some detail the primary issues of programme planning and related matters, we can turn to more specifics about projects. At the start, we need to ask ourselves: what is a project?

Definition

2.812 A project was defined in the **Strategic and Project Planning Budgeting** manual as "a discrete collection of R&D tasks which are required to fulfill a specific development problem". From this definition, we can isolate several important concepts:

***Discreteness** A project must be identifiable as a complete totality. Its boundaries must be clear and be easily distinguishable.

***Tasks** Within each project, certain activities must be specified or at least be specifiable. These are activities or tasks which must be undertaken for that project.

***Goals** All the tasks executed must be oriented towards achieving a particular goal. This goal must be explicit and must be couched in terms which can be understood by the staff in that project.

***Problem Solution** This is a more specific orientation in that a particular problem has been identified and it is expected that the problem can be solved at some future point in time.

2.813 In addition to the above definition, it should be pointed out that in defining the project boundary, we are also defining the project <u>resource requirements.</u> These resources could be specified in terms of time, money, materials, human resources, etc. For "neat" projects, all these requirements can be clearly spelt out while for many RDI projects, it may be much more difficult to have clear-cut boundaries.

A "neat" project is one which can be isolated in terms of human financial and material resources e.g. a road, bridge, building.

2.814 A project belongs in one and only one programme. While the benefits could cut across several programmes, the ideal position is that the project is an integral part of a given programme. In certain cases, however, a "project" can be consciously designed to cut across several programmes.

2.815 One such case that we came across in the course of fieldwork for this manual is what was called Adaptive Research Planning Team Project (ARPT), which was concerned with planning and coordination of research programmes (projects) in various commodities in one Southern African country. In this case, an integrated approach was required in order to have a measure of control on what was happening in various parts of the country. An approach of this type is also said to be multidisciplinary in that scientists from a wide range of research interests are brought together under one head for the purpose of achieving desired results.

If you are aware of any multidisciplinary projects in your country, list them below:

____
____
____
____

2.816 Project Planning is concerned with all that work that precedes actual implementation. This in a way suggests a clear distinction between projects and programmes. Projects are implementable while programmes cannot be implemented. Projects are also executable since there are discrete steps to be taken. Many projects also have a distinct starting point and a distinct end. Unfortunately, many RDI projects in agricultural and medical fields have no distinct beginning and/or end — they may even be perpetual. For instance, a "project" on tsetse fly in a given country may be seen as coming to an end when the tsetse menace is eradicated, but the time horizon may be so long that for all practical purposes, it is a perpetual project. Similarly, a project in the control of nematodes in spinach may never come to an end because as soon as a measure of control has been achieved in a given area, the problem may crop up in another part of the country. At the end, one merely moves from one part of the country to another in the course of trying to solve the problem.

List several such projects with which you are familiar.

Bibliography

Binning, K.G.H., "The Uncertainties of Planning Major Research Development", **Long Range Planning,** Vol. 1, No. 4, June 1969, pp. 48–53.

Cairns, R.W., "Planning for Research: The Problems Involved", **Research Management,** Vol. 4, No. 2, Summer 1961, pp. 107–118.

Fuller, O.M., "Techniques for Planning and the Small Experimental Project", **Chemistry in Canada,** Vol. 28, No. 10, November 1976, pp. 30–33.

Gargiulo, G.R., Hannoch, J., Hertz, D. B. and Zang, T., "Developing Systematic Procedures for Directing Research Programmes", **IRE Transactions on Engineering Management,** Vol. EM-8, No. 1, March 1961, pp. 129–132.

Gauvin, W.H., "Planning an Industrial Research Programme", **Proceedings of the fourth Annual Conference of the Canadian Research Management Association,** Vancouver, B.C. September 1966, pp. 129–132.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER III

PROJECT GENERATION AND FORMULATION

Project Generation and Formulation

Training Objectives

By the end of this chapter, the participants will be able to:

1. Explain how research projects are generated in RDIs.
2. Identify the characteristics of a good project.
3. Specify the criteria against which success or failure can be measured.

Project Generation and Formulation

Contents

This material can be covered in two sessions. If appendices are to be covered, another two sessions are required. Prior reading is a must.

CHAPTER III

Project Generation and Formulation

Introduction

3.111 In this chapter, we shall be discussing various aspects of project planning. We shall also give examples of how certain RDIs in the region go about planning their projects. In reading this material, it is hoped that the reader will learn of the strengths and weaknesses of the methods being used. This approach is based on the belief that one can learn from the experiences of others who have had similar experience in different environments. By carefully studying what is available, one may be able to select those aspects which are most suitable for their own RDIs and, perhaps, discard those practices which are not sound. In the process of this selection, an overriding consideration should always be the assessment of the increases in RDI productivity which will come about due to the adoption of a particular practice.

Project Generation

3.211 Anyone who has ever supervised a graduate student or undertaken higher level research work (as in doctorate work) will perhaps recall the agony with which one tries to come up with a researchable topic. Invariably, the requirements of the university authorities are that the research must be original, must address itself to a significant issue and must, at the end of the

Have you had this type of experience? Share it with others if you have.

exercise, make a contribution to knowledge. In a world full of undefinable problems or already solved problems, the graduate student goes through the whole exercise mortally terrified that the three criteria will not be satisfied or, at the very worst, just when the thesis is about to be submitted to the supervisors, a final run to the library to verify — for the last time — originality reveals that another thesis on an identical topic has just been published in another university on the other side of the country!

This is perhaps one of the most shattering experiences in research work. One can never be sure what people are doing!

3.212 This is a problem that plagues both graduate students and research scientists who are trying to be original. It has even been a concern for Nobel laureates who have independently and almost simultaneously arrived at the same solution to a significant problem, only that one of them gets his solution to the papers before the other!

3.213 Our concern here is with several related fundamental questions: Where do (research) projects come from? How are they generated? How do you tell that this is a good project or not? What measures of success can you propose as a contribution to knowledge?

3.214 In an attempt to answer these questions, we shall start from a purely analytical point of view. From thence, we shall proceed to discuss various methods used in actual cases found in the field.

3.215 In a book entitled: **Research Methodology and Business Decision,** Buckley has suggested a useful and highly analytical approach to the research method. In this book, he correctly stated that problem generation is one of the most challenging of the tasks a researcher has to contend with. This is because proper problem generation requires significant familiarity with the subject area in order to find out where any flaws or weaknesses in current and past research are to be found. In the following discussion, we shall use Buckley's scheme and relate it to RDI projects which, in many ways, are analogous to other academic research projects.

Would you agree with Buckley? Explain.

3.216 Buckley has broken down the area of research methodology into six interrelated parts:

i. Problem genesis
ii. Definition of the research problem itself
iii. Research mode
iv. Research strategy
v. Domain of research effort
vi. Techniques of actual research

3.217a **Problem genesis** is concerned with the preparatory work that goes on before a researchable problem is identified. This, as we have indicated, is no easy matter especially in the area of pure research. It is a process of search which culminates in the definition of the research problem itself. Buckley has suggested two approaches: using formal methods and using informal methods of problem generation. Within each category, he has identified various techniques which have been used in problem genesis and has suggested where each might be most useful. (See Appendix A to this Chapter for a brief discussion of these techniques).

How are projects (or problems) generated in your RDI? Explain in detail.

3.217b The next stage is **problem definition.** Whereas, this might sound trivial, it has been found that defining a research problem properly (in the scientific sense) is not an easy matter. The research scientist must state his problem in a manner that leaves no room for doubt regarding what he wishes to find out. Of this, more will be said in later sections of this chapter.

3.218 Once the problem is defined, it must be decided how it will be tackled. Two approaches have been identified: the deductive mode and the inductive mode. In the deductive mode, the usual approach is to follow the well known hypothesis testing style that is so common among social scientists. A research scientist on the other hand, may have no basis for setting up any hypothesis. In this case, he will have to depend pretty much on his training and experience (or even sheer luck) in solving the problem at hand. He may even come up with a tentative hypothesis which forms the basis of further research. A scientist using this style is said to be using the inductive mode.

When Darwin set out on his now famous mission which ended in the theory of evolution, he was most likely using the inductive methods. (There are philosophers who doubt that this method exists logically)

3.219a Then follows the issue of **strategy**. How, it is asked, is the actual research work going to be executed? In short, what is the primary focus of the data collection exercise? Four possible strategies have been identified:

- **Opinion strategy**
- **Empirical strategy**
- **Archival strategy**
- **Analytical strategy**

3.219b Opinion research is concerned with asking people as individuals or as groups, what they think or believe about a particular problem. It is a very common method in social studies but it has fairly obvious weaknesses.

What are these weaknesses?

3.219c Empirical study has something to do with physical reality. This is perhaps where most of the physical and biological science research is done. One can either go out and study what is happening in the field — as in doing an estimation of the prevalence of the *Anopheles* mosquito in a given district. Alternatively, one can conduct experiments in a laboratory. In medicine, case studies of patients with a given medical condition are also common.

3.219d Archival studies deal with records which can either be physical, primary or secondary. A physical record exists in the area of forensic medicine, for instance. It is an archive created by an active agent or nature. Primary records are generated through someone's experiment and all one is doing is taking them as they are found. Secondary data are records which have been collected, usually in summarized form, by someone else. Indeed, the most important difference between primary and secondary data is the extent to which the data has been aggregated or manipulated.

3.219e Analytical research does not involve physical phenomena. It is based on the internal logic of the individual researcher. Much of mathematics belongs to this category.

3.219f The **domain** of the research effort refers to the target groups or the source from which the data will be collected. This has been reterred to in the sections 3.219b to 3.219e above. Thus, for instance, the domain of opinion research is either an individual or a group of persons.

3.220a Finally, the **technique** to be used must be determined. These techniques are either formal or informal.

3.220b A formal technique is highly structured and is likely to use sophisticated equipment or survey instruments. These include actual instruments — microscopes, telescopes, oscillometers, etc. — or various techniques — research questionnaires, Delphi, content analysis, simulation, mathematical modelling, etc.

3.220c Informal techniques on the other hand are somewhat less rigorous and are thus subject to the weaknesses of the individual researcher or the vagaries of nature. The primary method is visual observation and then the derivation of conclusions from what is observed. Thus, Charles Darwin's famous conclusion on evolution could be classified as problem based on conjecture, using the inductive mode and the empirical strategy, in the field domain and using his great powers of observation. Other problem areas might be similarly classified.

You may wish to classify some of the research you are familiar with using the Buckley scheme.

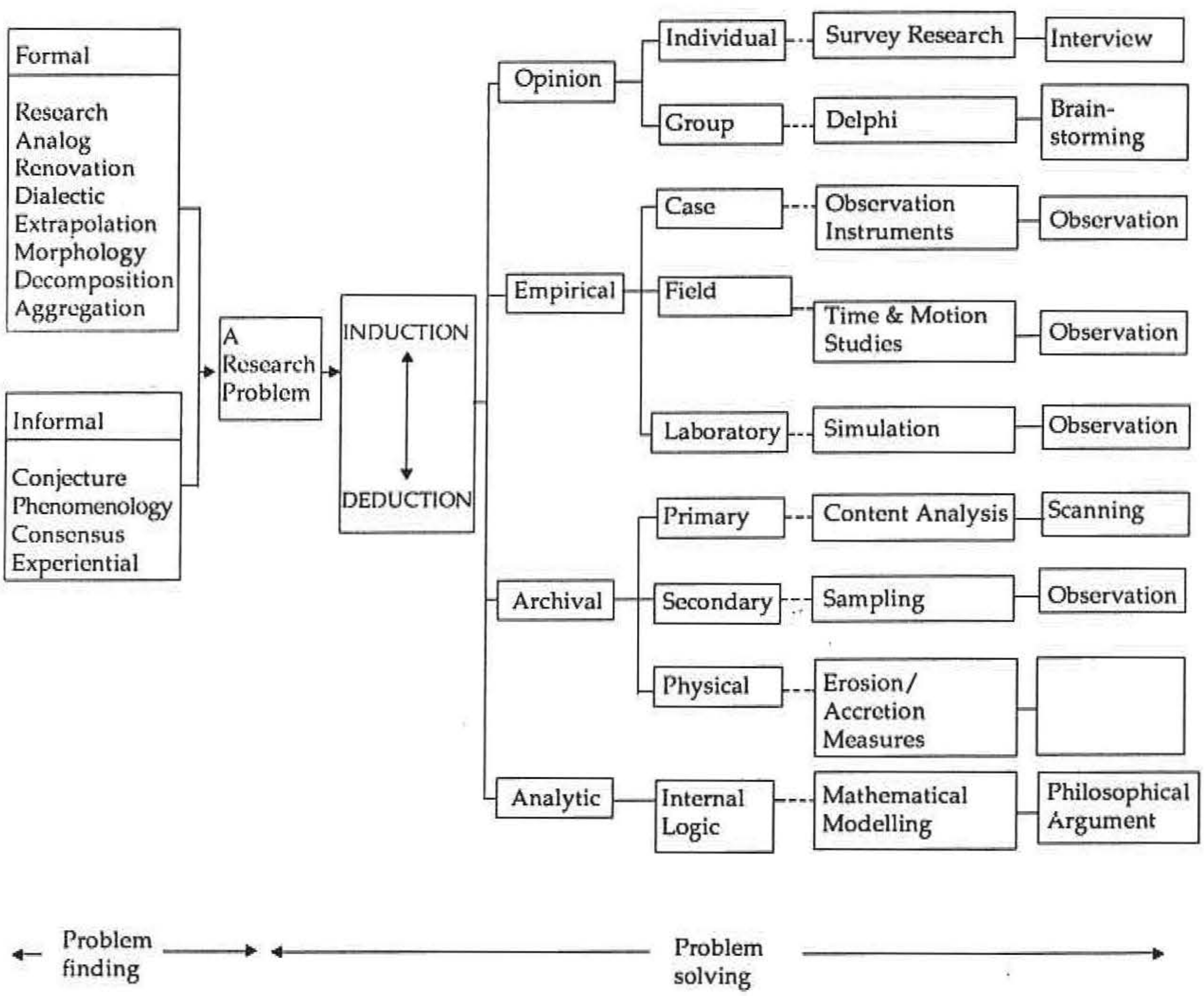
3.221 It should, from the foregoing, be clear that problem generation (or project identification) cannot be isolated from problem solution. The two parts are closely related and the successful researcher is the one who can see the problem in terms of all the various phases. This is not to say that there will be a solution for every problem . On the contrary there are many unsolved problems but we posit that they are unsolvable either because they are not fully understood or there is no method known to the researcher by which the problem can be solved. Figure 3.1 depicts Buckley's framework for research methodology.

Other Sources of Research Projects

3.311 The method which has been discussed in the first section is applicable where the scientist has to generate a problem or a project himself. It is a method which is used in original research institutions; such institutions are also likely to be relatively independent in their operations. In many cases, however, research problems or projects may be suggested from any other sources.

Table 3.1. A Framework for Research Methodology

I Problem genesis	II Problem	III Mode	IV Strategy	V Domain	VI Techniques Formal	Informal



Source: John W. Buckley, **Research Methodology and Business Decision**, NAA, 1976

3.312 A common source is the government. This comes about due to a problem — like locusts or armyworms — suddenly presenting itself and due to the nature of the problem, resources have to be allocated or reallocated immediately to deal with this problem. Another likely source is an influential member of parliament or a civil servant who wishes to have a particular problem solved because he has a personal interest in it. Alternatively, the problem could emanate from another institute which does not have the capability for dealing with the problem. A case in point is food poisoning in humans who eat half-cooked eggs. In these cases, the problem was observed in human beings but its solution lies in the domain of agricultural research. In cases like these, there is no difficulty in getting research projects; the difficulty is in solving them. We are sure, many RDIs in the region belong to this category.

The bioscientist recognizes this as the Salmonella problem.

Evaluate how given research problems became part of your RDI's research programmes.

The Project Concept

3.411 The final product of the preceding analysis should be a project concept or project idea. This is an idea which is researchable or executable. Like a good research problem, it is apparent that a good project should have some characteristics which should guide the scientist in differentiating good projects from the not-so-good projects.

Characteristics of a Good Project

3.412 A good project must be defined properly. It must be labelled and described accurately. As one writer has put it, "a common deficiency in research is to mislabel, inaccurately describe or otherwise fail to define a problem adequately". The same can be said of a project. As a case in point, consider two research questions which can be asked with respect to use of molasses as a supplement to dairy cattle feed: (a) Does the addition of molasses to dairy cattle feed increase milk production? and (b) What happens when you add molasses to dairy cattle feed? Both are researchable questions but the second does not direct attention to the key issue of milk production. It begs other questions before it can be answered scientifically.

3.413 The next point is the manner in which the project is presented. If the project requires the solution of a problem, then the questions must be posed in solvable terms. This implies that most, if not all, of the related methodological issues have to be clearly spelt out at the beginning as part and parcel of problem formulation or specification. It should be apparent that questions posed in global terms are unsolvable in the scientific sense. For instance, attempting to answer the question: "How can the quality of Maasai cattle be improved?" is likely to create a lot of other questions and thus, such a question is not a good research question.

3.414 The third characteristic of a good project is that it is connected logically to the environment from which it is drawn and its solution can be applied within that environment. This means that the project must be seen to be relevant to the people who will ultimately be asked to implement the project results. If they do not see it as benefitting them one way or the other, they may not see it as being of importance to them.

3.415 In this connection, we offer an example from a West African country where the problem was perceived to be the low yield of the local millet variety. Research efforts had diagnosed the problem as being poor millet yield. Experimental trial after trial was made and, in the end, a high yield millet variety was developed, tested for the usual scientific and economic properties and then it was presented, with all the extension work mapped out, to the local farmers to grow. After one season, practically all the farmers stopped growing the new variety and reverted to the old variety. Perplexed about this strange behaviour, a social scientist with an interest in adoption of innovations was commissioned to find out what had gone wrong. It was found that the only problem with the new variety was that the stalk of the millet plant was too short. The local people were using the stalk for two purposes — animal feed and, when dry, firewood. The short variety while satisfying the criterion of food supply to humans, failed miserably on two others. You may have had similar experiences in your own country. Think about them and how consideration of the entire problem and the application of its solution might run into unexpected difficulties.

List some such experiences you have come across. This case also demonstrates the need for an interdisciplinary approach to research in certain aspects of human activity.

3.416 The fourth characteristic should be obvious but it is frequently overlooked. A thorough investigation must be carried out to ensure that the project is unique — i.e., it must not be a repetition of another project which has been carried out somewhere or has been done at some point in the past in the same country. One way of ensuring that this does not happen is by having a good database of research projects in a given country and, secondly, making references to international sources before acceptance. While replication is obviously not forbidden, the replication of research experiments should only be carried out if there is a reasonable ground for believing that it will produce some additional and identifiable benefit. Merely replicating a treatment to show that it will NOT be successful in a given country or environment may not be a particularly useful contribution to knowledge.

Is there a well known and easily accessible reference bank of research projects in your country? A country in the south has already embarked on a data base for all agricultural research done in that country since 1952.

3.417 Finally, a good project should make a contribution to knowledge in one way or another. For pure research, the contribution may be extension of the frontiers of knowledge. For applied research, the unstated expectation is that research findings will improve the quality of life, for instance, or result in higher productivity, or produce animals or crops with greater disease resistance, etc. What result will be seen as making a contribution will obviously depend on the institution's mandate and national aspirations.

Are you in agreement with this observation? Explain.

How do you assess the value of a research project in your RDI?

3.418 The statement above may be fully appreciated in the following case. When we asked various directors about what they considered to be the most important factors in the success of a given project, the most common answer was "usefulness of the results to the country". This answer was probably not surprising since most of them were national research institutes. Other factors like scientific elegance, patents, publications, the amount of money spent, etc., were all considered relatively unimportant.

The question posed to them was: "What measure do you apply in judging the success of a given project?"
- *Scientific elegance*
- *Research results*
- *Number of enquiries*
- *Publications of research papers*
- *Usefulness of the results to the RDI*
- *Usefulness of the results to the country*
- *Satisfaction of scientists*
- *Amount of money spent*
- *New projects generated*
- *Patents registered*
- *Others (specify)*

3.419 One of the difficulties faced by the research scientist or even the project leader, is specifying in easily quantifiable (or at least understandable) terms, how success will be measured. What, for instance, is the meaning of the term "contribution to knowledge?" Can we be more specific about it, particularly with regard to applied research? We, would like to propose that in the project document there ought to be some measure of successful attainment of project objectives. It could very well be that if this is specified then the subsequent issues of monitoring and control will be more meaningful because there will be some benchmark against which efforts can be assessed.

Is there always, usually, rarely or never a criterion for measuring project success in your RDI's proposals?

Measures of Performance for Projects

3.511 For a given research project, the final goal, objective or end result should be indicated one way or the other. The result could, for instance, be stated in comparative terms. Thus, the objectives of a series of research projects could be stated as follows:

- To develop a maize variety which will lead to an increase in maize yield from 20 tonnes per hectare to 42 tonnes per hectare in six years.
- To find out what kind of animal feed will increase milk production for a given herd from 900 kg per year to 1500 kg per year.
- To develop a drug that will reduce tsetse fly concentration in Bingwa Valley to no more than 300 tsetse flies per square kilometre by 1995.

3.512 By specifying a relatively unambiguous criterion against which success or failure can be measured, the scientist is saying to his clientele and the world: If this and that has not been achieved, then you can very well ask me for an explanation and, I had better have my facts ready in good time!

What dangers, if any, does the researcher face in setting up such explicit criteria?

3.513 From the foregoing, it should be apparent that setting up these targets may require doing pilot studies or preliminary research. If, for instance, no one knows the concentration of tsetse flies in the Bingwa Valley, then a project should be set up with the objective of determining the current concentration of tsetse flies in Bingwa Valley. Such a project or pilot study is, in its own way, a contribution to knowledge on the presumption that the tsetse fly problem has been identified as being significant for the residents of Bingwa Valley — who could very well be rhinos, elephants and buffaloes!

3.514 At this point, we invite you to consider whether your RDI's projects are couched in terms which can lead to successful evaluation of project results. If not, how does the staff know where they are going or how? In what ways can your RDI's project presentations be improved in order to cater for this deficiency if it exists? What alternatives can you propose? What problems are likely to arise in the course of these alternatives being incorporated into the planning effort?

You may add other questions of your own.

Project Proposals

3.611 The proper and successful identification of a "do-able" project is just the first step in the long road to ultimate project completion. A lot of work still needs to be done before the project idea can be presented for consideration by the approving authority. The scientist has to get involved in considerable detail with all the basic research related to that project. This will invariably involve extensive library research in order to find out what has already been done in the area chosen for study. Masses of literature will have to be read, notes made and summarized in the quest for proper definition and delineation. Also to be considered are all sorts of methodological issues. It will be taken for granted that the researcher is already familiar with his own area of research and the appropriate methodology and has the expertise to apply it to particular research problems.

3.612 We, however, would like to suggest that the research scientist should be prepared to discuss all aspects of a project proposal with peers and/or the project director in order to establish the technical or scientific completeness of the proposal. Discussion with colleagues is a good source of critical review by people who are familiar with the researcher's work and have also certain common goals and objectives. Such feedback as comes from the peers should be taken

What is done in your RDI?

seriously. Negative comments should not be taken to imply that the colleagues are critical of the researcher's work. It is through such reviews that any weakness can be identified at an early stage and the necessary modifications or adjustments made before a lot of time is lost.

Definition

3.613a A project proposal is a statement in considerable but not excessive detail justifying the project, showing how it relates to programmes within the RDI and stating how it is likely to be of benefit to the country. It will include methods or procedures to be used and the resources, financial and human, required to complete the project.

3.613b The technical or scientific aspects of the proposal have already been referred to above. The next stage is to include a specific statement showing how the solution of the problem will help the country. Too frequently, this is an area stated in general or vague terms. In our view, this statement ought to be very specific: After all, if the country is being asked to spend a substantial sum of money, then it might as well be told how it is going to benefit from such expenditure. Justifying the project is the responsibility of either the research scientist himself or the project leader.

3.614 A project must fit in properly with other projects either in the same programme or in the RDI. The project leader's responsibility in this case is to ensure that the scientists within his control do not get carried away by their enthusiasm. In the proposal, the position of the project under consideration within the RDI should be stated explicitly.

3.615 A project also requires resources — men, materials, and money. All these have to be carefully estimated and then converted into financial terms. For personnel, for instance, it will be necessary to specify:

- The types of personnel required
- Their level of expertise
- Their numbers
- The length of time they will be in the project

- The cost of the personnel.

3.616 Similarly, for materials, a similar specification is required to show the types and quantities required and when they will be required. Their costs must also be estimated. Travelling and transportation also involves types of transport required — land rovers, trucks, bicycles, etc. — and the cost of fuel, repairs and other associated costs. Costs associated with these items will typically be available in the accounts office of many RDIs. It is the duty of the project leader to specify these well in advance and to have them included in the proposal.

3.617 In some RDIs, the technical part of the proposal is shown distinctly from the materials and money part of it. This is, we believe, the proper procedure and we recommend its use in all RDIs. Thus, the first part of the proposal will deal with scientific matters including justification. The second part will have the time and financial budget in considerable detail. But the proposal is one complete document.

Why is such a breakdown or separation a good thing?

3.618 In some cases, it may be suitable to show a suitable summary of both the technical and financial aspects of the proposal. Such a summary should be positioned in the first couple of pages before the main report. It can be useful for the busy executive who will not have the time to read all the details of the main report. Its purpose is to highlight only those matters that are of interest to higher level authorities. If this is the practice followed, then it is absolutely vital that such a summary be <u>endorsed</u>, in writing, by the project leader or some such person who will be held responsible for the accuracy and veracity of the detailed project. A common way of doing this is to have a standard form in which certain questions are asked and have to be answered by responsible persons. An example of this is shown in Appendix B to this chapter. The level of detail will obviously depend on the needs of the institution.

This is sometimes called an executive summary and may be all that senior people need!

This form can be improved upon considerably. Try to design a similar one for your own RDI.

3.619 For a detailed study of the manner in which project proposals can be done, we refer the reader to Appendix C of this chapter.

APPENDIX A

PROBLEM GENERATION

3.620 In **problem genesis**, as Buckley calls it, two basic approaches have been identified: **Formal** and the **Informal**. The formal approach, as he puts it, "implies the use of punctilious and methodical procedures while the informal is subjective and non-routinizable. Scientific genesis of problems requires a formal approach."

Formal Techniques

3.621 The following are formal techniques in problem genesis:

3.622 Prior research relies on previous research to chart out new problem areas. Such research could be deductive or inductive. This approach requires a lot of effort and keeping up with recent advances in the state of the art if one is to be aware of what is being done elsewhere.

3.623 The analog method uses knowledge gained in one area to formulate research questions in a different area. For instance, knowledge in the area of pest control in the large herbivores may be used in pest control in some smaller ruminants.

3.624 Renovation is used "to replace defective components with a view to restoring or improving the effectiveness of a theory". In this case, success is dependent upon ability to look at a system, detect the defective parts and work out a new and better technique or solution to the problem. Many RDI research projects are probably of this nature, for instance, in cases where a drug has lost its potency and a new drug — as in the case of malaria — has to be developed.

3.625 The dialectic method uses the well known method of asking whether there is a better method of dealing with a particular problem. Getting a new procedure implies that the old procedure is well understood and that the new one will be an improvement on the old ones.

3.626 Extrapolation consists of "extending current trends into the future and posing questions relative to the predicted outcome". This type of problem generation can be especially useful in new and uncharted research areas and is amenable to the Delphi method where known opinion leaders are iteratively asked what they expect the future of the area of interest to look like. It continues until consensus is reached. Extropolation relies upon a stable and discernible relationship in the continuum from the past to the present to the future.

3.627 Where there is no stable relationship, teratological analysis could be used. Teratology relies upon asking questions of a radical "what if" nature. An interesting "what if" question might, for instance, be in the current medical concern with "AIDS", the acquired immune deficiency syndrome. A question might be "If no cure is found in the next two years, what alternative does the medical profession have for containing the spread of the disease?" What if no cure is ever found?

3.628 Morphology is a highly formal technique for "analysing the combinatorial possibilities inherent in complex problems". An example derived from a morphology of jet engines has suggested that there are some 25,344 possible configurations for jet engines. In morphological analysis, problems (or as one person put it prospects) may suddenly present themselves which no one could have ever thought about if other methods were applied.

3.629 Decomposition is a technique which involves breaking down a problem into various parts. A large project could be broken down into small components for it to become manageable in the scientific sense. In a way, programmes have to be decomposed into projects and projects into sub-projects.

3.630 Aggregation is the reverse of the decomposition process. New projects or prospects can arise when parts of separate projects are combined; these would probably not have been there if there were no such combinations.

3.631 No doubt many research scientists have used these techniques in their work without being aware that they have a name. We have spelt them out in order to increase your awareness of the possibilities and to suggest ways and means of creating or generating research projects. Indeed, it is our belief and observation that much of the research RDIs in many developing nations have been developed through some or a combination of the formal techniques. They are given here so that the astute scientist can use them when his repertoire of research projects goes down — if ever.

Informal Techniques

3.632 Research problem finding can also utilize informal methods. We now turn to briefly look at these.

3.633 Conjecture is a powerful tool used in original research. It is "characterized by those situations in which the decision-maker has a hunch or intuitive feel regarding a problem area". This method is lacking in scientific rigour compared to the formal techniques but it is no less important. As some two writers have observed (Margenau and Bergamini): "Nothing is more astonishing about science than its ability to make imaginative conjectures and then convert them into tangible realities which no one had previously suspected. Out of Maxwell's equations of electromagnetism came radio and television. Out of Einstein's formulas on matter and energy came the atomic bomb. When scientific imagination works in the opposite direction, to crystallize theories out of facts, the transformation is equally dazzling. Here, in one decade, lies a musty lot of old bones and odd birds, and there, in the next decade stands the theory of evolution..."

3.634 Phenomenology is another informal technique and, as the name implies, derives its utility from careful observation of the scientific world around which one lives. In this case, an observation may appear as an aberration, or, at the worst, as an annoyance to the scientist. However, careful investigation may reveal, in fact, that it is an opportunity which had not yet been considered by anyone else. We can think of Alexander

Flemming's annoyance at his sample being ruined by a mould which, happily for medicine, led to the invention of penicillin. Or the "aberration" known today as Rontgen's X-rays.

3.635 <u>Consensual activity</u> may also bring about research activities. This is what was discussed in an earlier chapter regarding programmes. The essential feature is that a group of people sits down and agrees on research projects perhaps through a careful review of RDI mandate and consideration of national priorities. In some cases, a conference may come out with a list of research projects requiring attention during a given time period.

3.636 Finally, the greatest source of research projects is <u>experience</u> itself. Nothing can ever take the place of the experienced scientist in not only appreciating what problems exist in his own area or endeavour but also their uniqueness in terms of researchability or solvability. Many junior scientists regularly visit with their more senior counterparts to literally pick their brains <u>on what can be done</u>.

APPENDIX B

APPLICATION FOR FUNDS FROM UNIVERSITY RESEARCH AND PUBLICATION GRANTS:

Date ....

Name .... Department ....

....

Status ....

1. Detail outline of Proposed Research:

2. Is this a continuation of project or a new one? If a continuation please attach a detailed progress report of work done so far.

3. What has already been discovered about this problem and what remains to be done? Applicants are required to have investigated thoroughly the extent to which their field of study has been researched into or is being researched into so as to ensure information on a supplementary sheet.

4. Precisely what work do you propose to do, and what methods do you intend to adopt?

5. Is this a joint project, and if so, who else is engaged in the project? If a departmental or an inter-disciplinary project, please indicate the extent and level of collaboration.

6. Give an indication of the probable duration of work.

7. Give a general indication of:

   (a) the importance of the results which you hope to obtain,

   (b) the relevance and application of your research to the East African and, in particular, to the Kenyan situation, and

   (c) where and when you hope to publish the results.

8. In case the Committee wishes to refer your proposal to a referee give name(s) and address(es) of any person(s) you would like to be consulted.

9. Give an estimate of the total funds for the project and of the amount you are likely to request from the Research Grant Committee.

10. State any other bodies to which application:

    (a) has been made or

    (b) will be made for assistance in this project.

11. State in detail total funds required from Research Grant Committee for the year, under relevant headings, e.g. equipment, travel, subsistence, etc. It is essential that each item be costed with full details.

12. Are you already in receipt of a previous grant in aid of the proposed work? If so give details of your expenditure to date, and attach a brief report on the work done so far.

13. If funds are being requested for computer time or computer services, please ask the Head of the Computing Centre to comment on the proposed budget.

14. Comments by Head of Department under the following headings:

    (a) Does the proposed project fit in with the overall research objectives of the Department?

    (b) What priority and importance do you attach to the proposed project?

    (c) Have you examined the budget and if so, any comments on it?

    (d) Are other members of the department engaged in research in the same field?

    (e) Give an indication of the extent to which the department can support the project particularly with equipment, instruments, consumable items, etc.

APPENDIX C

PROPOSING

3.637 **Introduction:** We chose to add a unit on R&D proposal writing (to a workshop on planning and budgeting) because the R&D proposal represents the most comprehensive statement of both the desired ends of R&D, and the means for achieving them. The proposal is really the anchor for anyone involved in the project.

3.638 This appendix only highlights the role and methods of proposing R&D. It focuses, in particular, on the role of planning budgeting in R&D proposals.

3.639 Anyone can go to the proposal to find out what is to be accomplished by the project; what are the expected results. Anyone can turn to the proposal to find out how the expected results of R&D relate to national development needs. Anyone can go to the proposal to find out what resources are needed to achieve project results; or, what related technical work has already contributed to project completion. Anyone can read there, what technical steps are required to complete the project; and how they, and vital resources, are scheduled.

Do project proposals in your RDI tell:

(a) How expected results relate to national development needs?

(b) Why the project is the best alternative to fill this need?

(c) The scope and limitations of the project?

(d) The specific objectives of the project?

(e) Technical approach to the project?

(f) All resources needed for it?

(g) How the project will be managed?

The material in this Appendix is quoted from the FAMESA manual: **Strategic and Project Planning and Budgeting**, ICIPE, Nairobi, 1984.

3.640 **Definition:** In short the **project proposal** <u>is a statement of justification for the objectives, methods, resources and management of an R&D project</u>. It has many uses. At the project level it informs all project personnel about the purpose of their hopes and expectations in line with those of other managers responsible for RDI resources.

What are the purposes for an R&D proposal?

Who, in an RDI, will find it useful?

How will they use it?

3.641 At divisional levels, it helps convince managers to allocate resources to the project; and it gives them a basis for monitoring resources expenditure and technical progress.

3.642 At the top of the RDI it helps senior managers integrate all the institute's R&D into a programme which will have the greatest impact on national development needs. It keeps them informed on the technical elements of the RDI. It provides them a ready basis for explaining the RDI to constituents outside the institute.

3.643 Further, it is the first document in the life of any R&D project, which pulls together project purposes, plans and budgets (among other things). The project proposal provides the opportunity to integrate plans and budgets.

3.644 **Proposal Writers:** Who writes project proposals in your RDI? Accountants? Financial control personnel? Senior management? Divisional heads? Of course, it depends on the nature of the proposal and its intended uses. But generally speaking, project proposals are best when written by the project technical people who will be responsible for carrying out the R&D work.

Who writes R&D proposals in your RDI? Why are they the ones to write them?

Is there a role for accountants and other administrators in the writing of R&D project proposals? Explain.

3.645 As with project budgeting, they will need the help and consultative guidance of accountants, financial control personnel and senior management. But the principal effort is that of capturing, on paper, the purposes, processes and sequence of technical operations about which few others in the RDI may be qualified to comment.

3.646 **Proposals, Plans and Reports:** What are the differences and similarities of R&D project proposals, plans and reports? All three of them **focus** on the same thing, viz., the expenditure of identified resources, on specialized scientific processes, to achieve desired technical ends. But how do they differ? Let's start with definition of each of them.

What are similarities and differences among the proposal, plan and final report for a single R&D project?

3.647 We defined proposals at the beginning of this chapter. An R&D **plan**, on the other hand, is <u>a logical statement of the sequence of events leading to the accomplishment of specific technical objectives</u>. It may be a stand-alone document, like a workplan. Or it may be embodied in something else — like an R&D proposal.

3.648 A **report** could even contain a plan — depending on its purpose. It is a concise, written and/or oral, presentation of the planning execution, management or results of an R&D project. Its basic intent is to inform a naive audience about some aspect of the project. Whereas, the purpose of a plan could be to further enlighten and direct the efforts of project workers themselves.

3.649 The principal differences between these documents relate to issues of purpose, timing and levels of detail. In the first place, the proposal is written even before the R&D project has been approved for the RDI work programme; even before resources have been allocated for it. In fact, one of the earliest goals of the project proposals is to convince RDI managers and financial sources that the project is worth consideration for resource expenditures.

3.650 Secondly, the project proposal does incorporate information on the R&D process including tasks and methods, costs per task and total resources needed. However, it does so in less detail than does the workplan. In fact, the proposal provides sufficient detail to justify a decision on whether or not to conduct the programme of research. But decisions about actual resource allocations and scheduling await completion of the R&D plan. The plan is developed after a project has received at least preliminary approval for inclusion in the RDI work programme.

3.651 Finally, the project explains the real outcomes of R&D work. It relates what results from the effort, to what was hoped or expected (as based on the project proposal). Therefore, the report comes later than even the project plan.

3.652 A project report may come before the project is completed. For example, management may require quarterly reports of project progress. But it still focuses on outcomes, or results, of R&D work. And its principal point of comparison is the proposal, i.e., what was expected in the way of outcomes. Table 3.2 compares all three of these documents.

Looking back at your own RDI:

- *Do all three of these exist for each project?*
- *Where is each of them for any single project?*
- *Who wrote each of them?*
- *What are they used for?*

Who are the audiences for R&D proposals, plans and reports?

Are they the same? Explain.

Do they require the same kinds of information about the same project or programme? Explain.

Table 3.2. Comparison of R&D Project Proposal, Plan and Reports

Document	Purpose	Timing
Project proposal	1. Informs about expected results of the project	Before the project is approved or funded
	2. Refers to resources for the project	
Project plan	1. Informs about R&D processes required by the project	Immediately after the project is approved (at least tentatively)
	2. Schedules project resources	
Project report	1. Informs about real project results	Periodically during, and at the conclusion of, the project
	2. Basis for evaluating resource expenditures	

3.653 **Tie That Binds:** There is one element which binds all three of these documents together. It goes to the heart of this whole R&D management discussion.

3.654 All the R&D work of the RDI is designed to enhance national development — to somehow improve the status of life in a country. As we have said before, any management tool is simply servant of this greater goal. Proposals, budgets and plans are servants; supplies, equipment and even personnel are such servants. **Even managers, the director and the RDI itself are servants of a greater goal — R&D productivity for national development.**

What are the differences and similarities among:
- *project goals,*
- *technical objectives*
- *project results?*

Explain.

3.655 One consequence is that all project proposals, plans and reports have in common a status report on the project's relationship to that over-riding concern. The proposal tells how the project is expected to enhance national development needs; we call this portion of the proposal the "statement of project goals".

3.656 The project plan spells-out the R&D tasks for each goal and specifies just exactly what results

Why do we emphasize the statement in boldface type, in paragraph 3.654?

will be achieved by each task. We call these the "technical objectives" of the project.

3.657 The report details just exactly what was achieved by the project, or some task of the project. In other words, it provides an indication of how well the project is achieving its purposes. We call these the "results" of the project.

3.658 Project goals, technical objectives, tasks and project results are the closest possible approximations of the results of research and development — R&D productivity. They are the tie that binds all three documents together. They are the tie that binds together the RDI and all its human and other resources.

3.659 **Proposal Content:** R&D project proposals can have different contents, formats, even purposes. A lot depends on the nature of the project, the technical people involved, and the needs and requirements of the RDI for a comprehensive proposal. That notwithstanding, we propose the following thirteen basic topics for inclusion in an R&D project proposal.

Do R&D proposals in your RDI currently have all these parts? BLACKEN the right circle for each part.

		YES	*NO*
1.	Statement of Problem and Intended Uses of the Proposed Technology	O	O
2.	Goals of R&D	O	O
3.	Project Justification	O	O
4.	Scope and Limitations of the Project	O	O
5.	R&D Methodologies and Procedures	O	O
6.	Role of Project Beneficiaries	O	O
7.	Scheduling and Summary of Workplan	O	O
8.	Facilities, Organization and Personnel	O	O
9.	Budget	O	O
10.	Expected Outcomes of the Project	O	O
11.	Dissemination and Transfer to Beneficiaries	O	O
12.	Other Pertinent Information	O	O
13.	Summary	O	O

3.660 **Statement of the Problem:** Here is one of the first places where the R&D manager has the opportunity to cement the relationship between R&D and national development. **Here, at the very beginning of the R&D project deliberation, are stated the national development problems and opportunities which will be addressed by the proposed project.**

3.661 The purpose of this first section of the proposal is to explain those requirements for national development which will, at least in part, be fulfilled through completion of the proposed R&D. But it has to be remembered that whether or not this project gets funded may depend, in large part, on how well this first portion of the proposal is written.

3.662 If the author can show clear and imperative relationship between national development needs and project goals, then chances are good that priorities can be shifted in favour of the project. But if that relationship is not there, or at least poorly developed, then priorities may well shift to some other activities.

3.663 One good way to demonstrate the relationship between the proposed R&D and national development is to explain how the derived technologies will actually be used by the target beneficiaries. This also has the advantage of focusing all participants in the R&D process on utilization. It helps reduce the tendency in R&D circles to develop new knowledge and technologies which do not have an immediate application.

3.664 **Project Goals:** Many times, this first section of the proposal concludes with a statement of the R&D project goals. **Goals** are general statements of the desired outcomes of R&D. They make good conclusions of the earlier discussion of national development needs. Further, they make good introductory remarks for the next proposal section on R&D technical objectives.

3.665 Note, there must be an inherent logical consistency between any explanation of these three elements:

For each of the NO circles which you BLACKENED, above, answer the following questions:

- *Why isn't this part of your RDI's proposals?*
- *Should this part become an element of your proposals?*
- *Why, or why not?*
- *How would the addition of this element enhance your RDI's proposals?*

R&D productivity for national development starts here — with original statement of the development problem which may, in part, be resolved through successful R&D

What is the difference between the statement of a development problem, and a statement of an R&D project goal?

How do they relate to each other?

- National Development Needs
- R&D Project Goals
- Project Technical Objectives

What would we have to add to this list of three elements, to make a complete and logical statement about the national development and R&D? (See the answer below)

3.666 As an example let us return to our UHF Radio Receiver Project. Assume for the sake of the example that it is proposed by an RDI in a country which has a population that is widely distributed in a geologically and meteorologically active area. Let us continue by examining part of the Statement of Problem which accompanied the RDI's proposal for the UHF Radio Receiver Project:

Answer: Project Results

Statement of R&D Problem:

...Torrential rains, flash floods, earthquakes and typhoons, with their attendant damages to people and property, are not uncommon throughout the region. The need therefore exists for the government to provide an Early Warning System (EWS) so that all citizens may be warned of impending hazards, and may take preventive steps to protect themselves and their property...

One element of the EWS will be a radio instrument which is capable of receiving notifications of impending hazards, broadcast from the National Geologic and Weather Administration in the country's capital...

The UHF Radio Receiver must run for long durations on battery power, adaptable to solar or wind generation. It must be light weight (for portability) and must be able to withstand the onslaught of extreme weather conditions typical of subtropical regions.

3.667 Notice in this example how the discussion of the problem leads to specification of some of the vital characteristics of any proposed solution to that problem. That is the point of departure for a statement of R&D project goals. They might include the following:

Statement of R&D Project Goals:

...It is the intent of this project to develop the prototype and manufacturing specifications for a UHF Radio Receiver which has the following capabilities:

1. ...to operate on a Nickel-Cadmium power pack for an extended duration of 4 hours; or for an intermittent duration of 12 hours ...

2. ...to weigh no more than 5 kilogrammes for easy portability...

3 ...to have an effective receiving range of 500 kilometres.

3.668 Can you see a logical connection between the Statement of the Problem and the Statement of Project Goals? Which goals are directly supported in the statement of need? Which ones are not? How could the Statement of the Problem be enhanced to strengthen the imperative for achievement of the project goals?

Answer these questions.

3.669 **Project Justification:** By this time, the proposal reader has a pretty good idea of the need for, and the nature of, the proposed technology Therefore it is an important time to drive the argument home with a strong "project justification". The **project justification** is a succinct statement of the social, economic or political advantage for conducting the project. In our UHF Radio Receiver project we might cite economic reasons, like the amount of financial losses from property damage caused by tropical storms. We could cite the number of people annually made homeless by storms; and the attendant costs to government for resettling these people.

Why do we need to "justify" the project?

3.670 Two rules for this brief section of the proposal are that it should be succinct; that means it should be clear and brief. Further it should be persuasive. Persuasiveness is a ticklish matter. Many scientists interpret persuasiveness in terms of technical or research arguments. They overlook the fact that many of the readers of R&D proposals are not technical people. More often they are government bureaucrats who have only a layman's knowledge of science and technology.

Why is "persuasiveness" important?

3.671 Persuasiveness is achieved by writing arguments that are meaningful to the reader — that is, arguments based on social need, political expediency or economic opportunity.

3.672 **Scope and Limitations:** In the early part of any project proposal it is easy to leave the reader with the impression that the proposed project will solve all the problems described in the discussion of national development needs. Frequently, anxiety to acquire funding and support for a good

These are not reasons why the project will not succeed. They are clarifications of what the project will, and will not achieve.

project will lead us to overstate, or oversell, the merits of the project.

3.673 This section of any project proposal is designed to present the very real limitations, whether internal or external, technical, managerial, resource, or other, of the project. It is an opportunity to align everyones' expectations about what can be accomplished on the project — as well as what cannot.

Why should we bother to tell anyone what the project will not accomplish?

3.674 Rather than detract from the inherent persuasiveness of the proposal, this section frequently enhances the credibility of the technical people who will conduct the work — thereby reassuring the reader that they are not flying in the face of unrealistic optimism. Here is an example taken from our fictitious UHF Radio Receiver Project:

Scope and Limitations of the Project:

...not practical to fulfill all the requirements for the UHF Radio Receiver. For example, solar energy technology is not sufficiently developed to provide power for the unit under the overcast conditions which accompany torrential downpours during this country's rainy season.

Two other characteristics, however, will compensate for this deficiency. Nickel-Cadmium technology for storing electrical energy is well developed — thereby affording us the opportunity to exceed the requisite unregenerated running time. Further, wind generation, a well developed technology, will more than compensate for lack of solar capability because most of the regions to be served by the unit experience a minimum wind speed of 5km/hr, year around (the lowest threshold required for efficient generation of electrical power).

3.675 **Methodologies and Procedures:** This is the section in which the basic technological methods and procedures for this project are laid out. This should be written for the non-scientific reader — e.g., the government administrator who will advise cabinet officials about project funding priorities.

3.676 It is a good place to introduce the project tasks which will, later, serve as the principal units for planning and budgeting. They can first be introduced in a list; then described separately so that the reader obtains a pretty good idea of what happens in each one.

We developed the task list during the planning process. So which came first, the plan — or the proposal? How do they relate to each other? Who develops each of them?

3.677 **Role of Project Beneficiaries:** Throughout this course of instructions we have frequently alluded to the importance of including "beneficiaries" or "end-users" in the R&D process. This is too often ignored by government RDIs, around the world. It is more often done by private, for profit RDIs because their very existence depends on the satisfaction of clients.

Summarize the role of R&D beneficiaries ("end-users") in the R&D process — from project inception, through research, development and implementation of results.

3.678 We have discovered that technologies which are researched and developed with full participation of beneficiaries, are most often fully adapted, applied and integrated into the production process of the national economy.

3.679 Therefore, we are here recommending that each and every R&D proposal contain a brief section which specifies the role of target beneficiaries in the R&D process. This includes everything from needs assessment before a project is planned, to impact evaluation after the derived technology has been disseminated.

3.680 **Scheduling and Summary of Workplan:** A natural follow-up to the discussion of project schedules. For example, a simple bar chart which arrays tasks over time will help introduce the time element to deliberation about this project.

What other techniques could be used to show the relationships among project tasks, and schedules?

3.681 During this discussion it is important to emphasize any time considerations which impinge on the project but are not under the control of the project. For example, the upcoming rainy season with its attendant damages to people and property adds incentive to get the UHF Radio Receiver project underway as soon as possible. A possible time constraint that is worthy of mention could be the time required to import certain parts, or technologies from abroad.

3.682 After a discussion of the major facets of scheduling, this section should conclude with a refined workplan. This is a good place to include a Bar Chart, or a Deliverables Chart. But it should be accompanied by sufficient words for a naive reader to interpret it accurately.

3.683 **Facilities, Organization and Personnel:** This is where we begin to note other resources which will be required to complete the project. It is also a place to highlight those RDI equipment, facilities, and specialized personnel which make this project particularly well-suited for this institute.

What are the RDI's unique capabilities to conduct this project?

3.684 It is the beginning of the discussion on how the project will be managed. What laboratories will be involved; what personnel; who will be the key project technical people; where will the responsibility for project control fall? These are some of the issues raised in this section.

What is the management plan for the project?

How will costs be monitored and controlled?

3.685 Again, it is not important to be comprehensive. It is important to be informative and to highlight the most salient considerations for project selection purposes.

How will scheduling and technical performance be controlled?

3.686 **Budget**: Finally, we come to the budget section of the proposal. This is the budget which we derived earlier. It is the basis for funding requests of higher levels of management. It is particularly important to highlight the capital budget.

Which comes first, the budget or the project proposal?

3.687 After the project has been approved, on the basis of this proposal, and funds have been allocated, it will most likely be necessary to redesign the project's working budget. This is because few RDIs are able to provide the same amount of funds as requested for R&D projects. So project schedules, or even deliverables, may have to be altered — requiring a commensurate change in financial flows and totals.

What is their relationship? Who develops each?

3.688 **Expected Outcomes of the Project:** By this point in the proposal, the reader has become immersed in numerous details of the proposed technology, and the R&D processes. Here is a useful place to recapitulate, for them, the expected products which will result from the R&D activity. It need not be, indeed should not be, discursive;

Why is it important to add expected outcomes of the R&D here, especially when it was said earlier in the proposal?

because, all of it has been said before. In fact, a concise listing of expected end products with one or two sentences describing each one may suffice. This section helps the reader keep their mind on the ultimate goal and impact of the proposed project.

3.689 **Dissemination and Transfer to Beneficiaries:** This element is too often ignored by R&D proposal writers. It is designed to answer the question, "Well, how will you get the technology out of the RDI and into the hands of the people who should benefit most from it?". This is a very important question because it turns out that the requirements of dissemination and transfer can have a profound effect on the character of derived technologies.

How many of the R&D proposals currently in your RDI talk about how the new technologies will be transferred to the beneficiaries?

3.690 For example a UHF Radio Receiver which requires the user to have a degree in radio electronics is far less practicable than one which requires no training for the user at all. In the agricultural sector, R&D which requires transfer through extension workers is acceptable where such an outreach system is in place. But what about a country in which the extension service is poorly organized and under-staffed?

3.691 This section of the proposal should outline, briefly, the characteristics of dissemination and transfer of derived technologies to the intended users. It should conclude with language about the influence of dissemination methods on the technical qualities of the proposed work.

3.692 **Other Pertinent Information:** This is an opportunity to say anything which may enhance the proposal; or at least which should be part of other managers' consideration as they select projects for the RDI portfolio.

What kinds of information will your RDI research leaders have to include in this section?

3.693 This information may relate to national development needs; technologies; resources required; deliverables; project management; or anything else. It is a good place to highlight particularly advantageous considerations about the proposed project. It is a good place to, again, recapitulate the project justifications.

What other information is important for the consideration of project proposal readers?

3.694 Finally, the APPENDICES of the proposal may incorporate a variety of important details. They may be technical results of pertinent studies; data on user needs; feasibility study reports; glossary; instrumentation; bibliographies; or other types of information. It is important that these inclusions be meaningful to the reader who wishes to probe deeper into the details of the proposed work.

What are the criteria for deciding whether a particular piece of information should be in the APPENDIX or in the main body of the proposal?

3.695 **Summary:** Yes, this too, is a vital element of any good project proposal. It should be written last — that is, after you have all the data necessary for the other parts. It should comprise 3–5 pages and should be appended right up front — after the title page and table of contents. That way it is front-and-centre for those busy bureaucrats who have no time to read more detail.

Who is the target audience for the proposal summary?

What information should be in the summary? Where should it appear in the proposal?

3.696 Needless to say, this summary should overview the proposed project, starting, again, with the national development needs. It should highlight project objectives and deliverables; significant technologies; particularly compelling management issues; and resource requirements. It should close with a reiteration of the national development needs which will be addressed by the outcomes of the project.

3.697 **Case 1** presents the recommended contents of project proposals forwarded by R&D personnel of an industrial RDI in Eastern Africa. Notice that while they differ in sequence from the contents we have just advocated they offer the same overall information. In a foreword to this prescription the RDI director states:

> It should be clearly understood that there is no rigid formula for writing a project proposal and that the format presented here is a guide which can be modified suitably to reflect the ingenuity of the author, and the requirements and expectations of potential sponsors of the project.

3.698 This particular RDI conducts some projects for clients in the private sector. That is the reason for the last admonition: "...requirements and expectations of potential sponsors of the project."

***Case 1:** INDUSTRIAL RDI PROJECT PROPOSAL OUTLINE*

An industrial RDI developed some proposal standards in 1981 which have dramatically eased the burden of R&D project selection because they are:

- *uniform for all projects*
- *comprehensive in information they provide*

Their outline is as follows:

1. ***Title:** it must be descriptive of the project.*
2. ***Introduction:** of the problem, its importance and scope.*
3. ***Objectives:** of the project (focus on outcomes).*
4. ***Background:** to the project; including previous related work.*

3.699 But it is equally valid for those RDIs who conduct R&D at the behest of government alone. In this case, government is the "sponsor" or the client. And, as we are sure you can testify, government has its special tastes and preferences for the manner in which information is submitted to it.

3.700 So the point is that while all R&D proposals will probably have the same kinds of information in them, the format and presentation of that information should adapt to the special characteristics of the R&D clients and sponsors, technical specialists, technical goals and objectives and management requirements.

3.701 **Proposal Reviews:** Some RDIs go through elaborate review processes for their annual crop of R&D proposals. Others do not. It depends on the quality of work done in the RDI, the amount of control that is desired, the type of technologies involved, time available, and the management styles dominant in the RDI.

3.702 Suffice it for us to encourage all RDIs to develop some limited capability for technical directors to obtain peer reviews of their proposals, during the drafting process — i. e. , before they undergo final evaluation for project selection and funding decisions.

3.703 **Peer Reviews:** Peer reviews are those conducted by people who are equal to the proposal writers in either, or both, of two characteristics; technology and management capability. Both perspectives will help the writers hone the proposal to its most communicative essentials. Their "peer" qualities will enhance reviewers' credibility as critics for the proposal writers. They will also remove the threat of penalties for unsatisfactory work.

3.704 The purpose of peer reviews is to derive improved project or programme proposals (or reports). In other words, all participants must commence a peer review with the general belief that all work can be improved; and that each "peer" has a point-in-view which is worth consideration. In other words, a peer review

5. ***Justification:*** *social and economic benefits of the project.*

6. ***Work Programme:*** *logical sequence of R&D tasks plus schedules and staffing.*

7. ***Costs:*** *personnel (plus overhead); capital equipment; stores and services; communications; travel and transport.*

Conclusion: *Summary plus future trends and possibilities.*

Should a project proposal contain a debate of the technical merits and demerits of alternative methodologies considered for the project? Why, or why not?

Should a project proposal contain a summary of the technical literature related to the subject of the project? Why, or why not?

should take the form of a discussion of a work's strengths, and opportunities for improvement, among colleagues.

3.705 Other review practices may be adopted. For example, some RDIs annually develop a panel of "external" reviewers who examine all proposals coming from the institute in a year's time. The use of external peers is an attempt to ensure some objectivity in the selection of projects for the RDI portfolio. Other times it may be an attempt to build-in to the review process, technologies and expertise which are not present in the RDI staff.

3.706 But whatever your review practices, develop and standardize some. Reviews are healthy, educational, and beneficial for the whole institute. They go a long way toward keeping the institute's work goal-oriented and of the highest technical quality.

Who regularly reviews project proposals in your RDI prior to their final submission?

What criteria do they apply in their reviews? What are they looking for? Why are they looking for that?

How could the proposal review process in your RDI be changed to improve the quality of R&D?

Bibliography

Ayres, Robert U., **Technological Forecasting and Long Range Planning**, McGraw-Hill, New York, 1969.

Buckley, J.W. , **Research Methodology and Business Decisions**, National Association of Accountants, 1976.

Bunge, Mario, **Scientific Research I: The Search for Systems**, Springer-Verlag, New York, 1967.

Bunge, Mario, **Scientific Research II: The Search for Truth**, Springer-Verlag, New York, 1967.

Kahn, Herman, **On Escalation: Metaphors and Scenarios**, Preager Press, New York, 1965.

Kaplan, Abraham, **The Conduct of Enquiry, A Methodology for Behavioral Science**, Chandler Publishing, San Francisco, 1964.

Mason, Richard O. "A Dialectical Approach to Strategic Planning", **Management Science**, Vol. 15, No. 8, April 1969.

CHAPTER IV

PART I

PROJECT MONITORING, CONTROL AND EVALUATION

Project Monitoring, Control and Evaluation

Training Objectives

By the end of this chapter, the participant will be able to:

1. Define the terms monitoring, control and evaluation.
2. Explain the role of monitoring, control and evaluation in the management of projects.
3. Describe the various measures of performance for projects — technical, schedule and cost performance.
4. Describe the procedures for monitoring, control and evaluation of projects.
5. State the basic assumptions in monitoring, control and evaluation.

Project Monitoring, Control and Evaluation

Contents

All this material can be covered in one session as it is introductory.

CHAPTER IV

PART I

Project Monitoring, Control and Evaluation

Recapitulation

4.111 Project **planning** involves the determination of tasks to be performed, their sequence, their duration and the resource requirements.

4.112 Once a plan has been completed, a **budget** is prepared. A budget converts the tasks and resources required into a common denominator, i.e. money. It shows how much must be spent to complete each task and also the total for the whole project.

4.113 Armed with a project plan and a budget, the researcher is in a position to prepare a **project proposal**. The proposal is necessary to solicit authorization or funding. Hopefully, the proposal is accepted and this marks the end of the first phase in project management.

4.114 At the end of the project life, an **evaluation** is carried out to find out what has been achieved and what lessons can be learnt from the project. In a way, the stages above, taken as a whole, constitute Research and Development Management.

PLANNING

+

BUDGETING

+

SELECTION

+

IMPLEMENTATION

+

MONITORING

+

EVALUATION

=

R&D MANAGEMENT

Introduction

4.115 This chapter of the manual deals with **monitoring, control** and **evaluation** of projects. Make sure that you understand the sequence of activities outlined above. This understanding will enable you to comprehend the role and importance of monitoring and control of projects as well as their on-going evaluation.

Monitoring

4.211 Monitoring is the on-going process of observing, recording, analysing and reporting data during the implementation of an activity. The purpose of monitoring is to achieve sufficient and effective programme performance and by providing feedback to management at various levels.

This enables management to:

- Compare progress of work against objectives
- Detect deviations from plan
- Identify bottlenecks in work flow; and
- Take corrective action in the course of project implementation.

Monitoring is an integral activity and a necessary part of the management information system.

4.212 In monitoring on-going research projects, the primary focus is on quality and performance of the project vis-a-vis the research programme in which the project falls. Such focus will include decision-making procedures, project and programme leadership as well as the adherence by research scientists of accepted research documentation and progress reporting. Included in this area are also elements of personnel management, financial control and the management of the project's physical resources.

Effective progress reporting requires specific penalties for failure to meet predesigned deadlines. How is this done in the case of your RDI?

Controlling

4.311 Controlling, in the context of project management, is inseparable from the monitoring aspect. Indeed, there can be no control without monitoring. Controlling is ensuring that the project proceeds according to plan· it is also concerned with deciding what and how changes in the implementation programme will be made in such a way that by so doing, the chances of successful completion are increased. Controlling is a managerial activity which relies on information provided to project management; it therefore suggests that the information provided is accurate relevant and reliable. It must also be capable of independent validation or verification.

Who provides such information in your RDI?

4.312 Controlling may in some cases suggest a change of the original plan. This is perfectly acceptable since information may become known in the implementation stage and this information may not have been available when the project was being planned. When new directions in the project are being considered, their effects and/or consequences should be fully considered before they are implemented. There are cases when interruption or a change in direction may not be justified on economic grounds.

Why is it necessary to verify or validate such information?

4.314 Contrary to popular belief, control in the scientific sense, is not a bad thing. It does not imply making people change their behaviours or take actions which they may not have taken voluntarily. Control is a positive and necessary aspect of management because, without it, it is not possible to direct energies in an orderly manner towards the achievement of organizational objectives.

Evaluation

4.411 Whereas the project may be going on as planned and is running on course in financial resource usage, it does not necessarily mean that it is still a valid project in the context of hind. Project evaluation therefore is concerned with the on-going analytical process whose purpose is to determine whether the project quality and relevance during the implementation is at an acceptable level. Using information derived from monitoring and often as a result of problems or prospects identified through monitoring, evaluation may suggest that a new method ought to be used in the solution of the original problem or that an action of a more strategic nature ought to be taken. Such an action may be changing the project objectives or even terminating the project altogether.

4.412 Project evaluation is a matter for project leaders and institute directors and, sometimes, the research scientists themselves. It involves asking questions which the scientist himself may not be in a position to answer objectively because of his involvement with the project. Many are the instances when the scientist involved may feel psychologically obliged to protect the project even when he knows that it is not going on well or is considerably behind schedule. At the extreme, cases are known when research data have been modified to fit in with the results that the scientist wanted to show. The scientist himself cannot be the judge of his work. A panel of experts' collective wisdom is a much better alternative than an individual's opinion. We suggest strongly that on-going evaluation be done by a panel which includes senior personnel in the RDI.

You must have come across many instances of this nature. List down a few of them and try to identify when the project went "out of control"

4.413 In summary form, the relationship between project monitoring and evaluation can be seen as depicted in Table 4 .1.

4.414 In this scheme, data is distinguished from information. Data, in the context of information systems, is defined as "the raw material that is processed to provide information". Information, on the other hand, is "data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective decisions." (Davis, p. 32–33).

How do you distinguish data and "information"?
Does the distinction have practical importance?
Explain.

Table 4.1. Comparison Between Monitoring and Evaluation

Parameter	Monitoring	Evaluation
1. Objective	To determine if the project is going on according to plan	To determine if the project objectives are being achieved as expected
2. Frequency	Ideally a continuous activity	Is done at specific points in the duration of the project
3. Focus of attention	On specific aspects of the project	On total project in relation to objectives
4. Performer	Usually the individual scientist or his project head	A team of independent scientists who need not include the scientist(s) directly involved
5. Possible action	Correct deviations from plan to get the project back into control	May involve a change of plan or even the termination of project
6. Data requirements	On a continuing basis as the project progresses. Data capture is essential	May use information supplied through the monitoring process

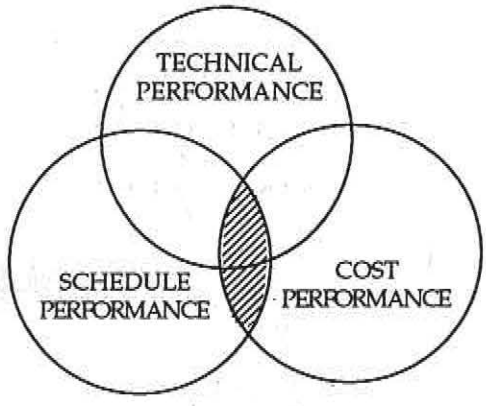
Elements of Monitoring and Control

4.511 In any project, several related elements are supposed to be monitored so as to allow for the control of the project activities.
These are:

- The technical elements of the project i.e. the tasks to be performed;
- The timing and duration of each task, i.e. project scheduling; and
- The cost of each task and of the project as a whole.

4.512 The above three requirements may be depicted pictorially as shown in Figure 4.1.

Figure 4.1. Elements of R&D Project Monitoring and Control



4.513 Monitoring and control involves all the three aspects and is not complete until each of them has been taken care of. In any one research project, however, some of these aspects may dominate others. For instance, in an attempt to develop a cure for a dreaded disease e.g. "AIDS", technical performance and time performance may tend to dominate cost performance.

Project Performance

4.611 We control and evaluate R&D projects in order to maximize R&D productivity. We wish to produce the best output within the stipulated time and at least possible cost. Many research scientists emphasize the first objective at the expense of the other two. This should not be encouraged since all the three are important from the perspective of the RDI.

Explain the meaning of R&D productivity with your own RDI in mind. What are some of the measures of RDI productivity?

Technical Performance

4.612 Technical performance is concerned with the quality of the project. It may refer to the manner in which the project is carried out or in the scientific structure of the results. A project that has a high degree of technical performance is one whereby scientists involved will consider it to have been soundly planned and properly executed. Technical performance is analogous to efficiency in that the execution has to be done in the best manner possible using the best available technology.It also has something to do with effectiveness if a project does not do the job it was expected to do

What does "quality" mean in an RDI?

effectively, one could say that it is not effective. For instance, the most effective way of exterminating mosquitoes in a given area of land is to spray the whole area with a highly toxic chemical that is known to kill all types of mosquitoes. In the process, however, of killing mosquitoes, a lot of other insects, fauna and flora may be wiped out. One does not wish to use such a solution. Certain trade-offs are therefore unavoidable in spite of the technical efficiency of a project.

How do you define technical performance in your RDI?

Schedule Performance

4.613 Schedule performance refers to the ability to complete the various tasks in a project within the time allocated to them. This is a bit problematic in R&D work. It may seem all right to set time limits but we should always remember that scientific insights are not easy to programme. A scientist may spend many years trying, for example, to develop a new cassava hybrid without success. We cannot regard this as time wasted because the work done may form a good basis for a similar project in the future.

4.614 Despite the above reservations it is necessary to set up a time schedule for the purpose of evaluating and controlling research projects. But failure to meet a given schedule should be carefully evaluated before a decision can be made regarding what might have gone wrong. This evaluation should be able to show whether failure to maintain time deadlines was due to controllable or uncontrollable factors.

What is the policy in your RDI when it comes to setting up time schedules for projects?

List, for a project you are familiar with,
(a) controllable factors
(b) uncontrollable factors

Cost Performance

4.615 Cost performance refers to the ability to complete the project within the funding limitations set out in the project plan. Requests for additional funding are not always approved and may cause delays in project continuation. For this reason, ability to complete the project within the limits set may be the key determinant to whether the project will be a success or a failure.

In your own RDI, what proportion of projects is completed within the cost limits originally set up?

6.616 Some research scientists feel that many worthy research projects are commonly underfunded. This may be true. What, however, is not often realized is that funds are a scarce resource and that people who make funding decisions have to ration out limited funds among many competing ends.

Who is responsible for such underfunding?

4.617 The technical, schedule and cost parameters are detailed, first, in the project proposal. Then, after the project is selected for resource allocation and implementation, a working plan is devised for the project. At this time, the budget may also be revised to reflect the most realistic expenditure of available resources. This will, of course, involve revisions of the original estimates of technical specifications, time schedule and costs.

4.618 If monitoring shows that a particular project is deviating from planned targets, one solution is to change our expectations, i.e. re-plan the particular parameters involved. This is a perfectly legitimate control strategy as long as it is not abused. Before any plan revisions are made, one should be absolutely sure that the cause of the deviations from planned targets does not lie elsewhere, e.g. inefficient use of materials, poor management, etc. The only time when plan revision is necessary is when we discover that the original plan is too idealistic to be attained.

When a project has gone in directions not planned for, what do you do in your RDI?
How often are revisions made in your RDI?

You may very well ask why it was set at such a level in the first place? It may be a reflection of initial poor planning!

Mechanics of Monitoring and Control

4.711 There are six steps in monitoring and controlling R&D projects. These are:

- **Planning**
- **Allocation**
- **Implementation**
- **Measurement**
- **Analysis and Evaluation**
- **Adjustment**

Planning

4.712 Defining technical tasks and budgeting financial resources comprise planning. Planning establishes the expectations against which we monitor and control project performance.

Allocation

4.713 Allocation refers to the specifications of the resources to be deployed to the project. Once the project managers are told they may proceed to expend RDI resources on the project, allocation is said to have taken place. Authorization in government funded projects may sometimes take a long time and this delay may harm the project considerably.

How is the allocation activity done in your RDI?

Implementation

4.714 Implementation means doing the technical work specified in the project plan. Whether implementation is carried out properly or not, i.e. within the planned parameters, is partly a function of the time and financial resources available. But, more importantly, it is also a function of technical conditions that obtain when the implementation is in progress. Some of these conditions may not have been anticipated in the plan. In R&D work, this is a common occurrence. Sometimes the original plan has to be suspended temporarily so that some technical problem that has arisen can be solved.

List some of these technical conditions:

____
____
____
____

Measurement

4.715 Measurement is virtually synonymous with "monitoring". It means systematically recording performance on all parameters in order to detect the earliest available signs of any deviations from planned performance. Measurement requires that "instruments" to carry out the measurement be available. Where these are not available the researcher might have to invent some. The ability to reduce every observation to a mathematical number is the mark of scientific maturity.

How do you deal with measurement problems in your RDI?

Give your own definition of measurement.

Evaluation

4.716 This involves deciding whether or not:

- **Performance is deviating from plan**
- **The deviation is within acceptable limits**

If an unacceptable deviation is detected, then the cause of the deviation has to be investigated. Whether evaluation is done properly or not depends on our ability to measure performance. This, in turn, depends on the measurement technology available. It also depends on the timing of the evaluation. If evaluation is only done at the end of the project then there is very little corrective action that can be taken. Evaluation also involves determining whether the project is still valid in light of changing conditions within and without the RDI.

Whose responsibility is it, in your opinion, to detect deviations from plans?

Adjustments

4.717 Once it has been determined that a particular activity has deviated too far from the plan, then it is the job of project management to take some corrective action. The nature of the adjustment required may involve one or more of the following alternatives:

- **Putting in additional resources**
- **Changing the time schedules**
- **Addition of a new technical activity**
- **Suspension of the project**
- **Termination of the project**

It is also possible that none of the easier options can be taken. Then, in such cases, planned expectations have to be marked down. In the extreme, the project might have to be abandoned altogether. This should not be regarded as unusual in R&D work. Remember that right from the beginning we are trying to create something new or to solve a problem. It might be the case that the current state of scientific knowledge does not allow us to do this. Ideally this situation should have been identified in the initial stages but in reality this may not always be possible.

The final decision regarding which action to take is a matter for the management of the RDI and, in some cases, perhaps the Council. What authority in your RDI is responsible for these types of decisions?

Basic Assumptions in Monitoring and Control

4.811 There are some critical assumptions underlying any monitoring and control system. It is important to assess them in each R&D project so as to determine if they are applicable to that particular situation. If they are not applicable, then monitoring and control is not possible.

4.812 Monitoring and controlling any R&D project is based on five assumptions:

- **that project performance can be measured**
- **that personal responsibility for the performance of the project exists**
- **that time required to monitor and control is worthwhile**
- **that deviations and mistakes can be discovered in time, and**
- **that corrective action is possible.**

Measurability

4.813 We have already dealt with this aspect. Before a project is even started, consideration should be given to the kind of measurements that will be necessary and how these measurements will be performed. All the instruments that will be required to carry out the measurement must be identified and acquired. If new instruments have to be invented then this should be provided for in the plan. At the risk of exaggeration, one may say that R&D is first and foremost measurement. If you cannot measure, it is unlikely that you will succeed in any R&D project. Some projects cannot be done at the moment because nobody has as yet figured out how to do the measurement.

What standard instruments are used to measure performance in your RDI? Do you recall any instances when you have had to design new "instruments" to measure some project activity?

Responsibility

4.814 We would like to be able to assign responsibility for the performance of the project. This was relatively easy when one single researcher used to be responsible for initiating, executing and concluding a project. However, this is no longer possible. Research projects are today the responsibility of teams of researchers and not individual persons. Who then is to be held responsible?

These are referred to as "stand-alone' projects.
Name some you are familiar with:

____

____

____

____

4.815 Should we hold the team leader responsible? This would be wrong. Each of the specialized tasks in the project is usually under the responsibility of a specialist in that area. So, in a way, he is a boss of himself. Worse still, the various tasks are so inter-connected that the performance of one affects performance of others.

So who is to be responsible? Nominally, the team leader is held responsible for the whole undertaking. But we should be aware of the limitations of his influence. Perhaps the most important skills he will bring to bear on his job are not the technical ones but the human ones, i.e., his ability to get on with his colleagues and to motivate them to exert themselves to the heights of their ability.

Recalling what was said earlier about leadership styles, what style is appropriate in a "complex" project?

4.816 In addition to our inability to assign responsibility to an individual there is the question of whether responsibility should be allocated to the researchers at all. It is possible in an R&D project for everybody involved to exert himself to the hilt and still produce mediocre results. Things may not work out properly because nature is unwilling to release her secrets and not because the researchers are not trying hard. The big question is: How do we decide who takes responsibility if things do not work out as expected? It is not easy to answer this question.

Who takes responsibility in your RDI when things go wrong?

In your own experience as a scientist, recall a case or cases where nature has refused to "cooperate". It could be a useful discussion point.

Cost Aspects of Monitoring and Controlling

4.911 We must consider the cost of monitoring and controlling a project. Remember that monitoring and controlling will involve expenditure of resources. What we should do is compare the cost of monitoring and controlling against the benefits. How does one go about this?

4.912 The costs are relatively easy to identify. They include costs of instruments and staff to operate them, cost of time spent analysing the results and devising corrective action.

List some costs in R&D work:

4.913 The benefits of monitoring and control, unfortunately, are not easy to quantify. One can think of such things as cost savings and superior performance. But how is this superior performance to be converted into **monetary values** or some other easily understood numbers? In many situations, this form of analysis is suppressed for lack of data. But this is not the correct course of action. Even though we cannot quantify the benefits, we should take them into account. Perhaps a qualitative evaluation is all that can be done. But we should not ignore the issue.

Is this type of analysis done in your RDI? If yes what approach is taken?

In the space below, list some qualitative benefits of a project with which you are familiar:

Discovery of Deviations and Mistakes in Time

4.914 If deviations and mistakes are discovered in time, then corrective action may be possible. But if the discovery is late there is, perhaps, nothing that can be done. In such cases, monitoring and controlling becomes a worthless activity. In many R&D projects, ability to discover deviations depends on how structured the research is. If one is attempting to develop a new product for which all the basic scientific knowledge is available, then, monitoring and controlling can lead to early detection of deviations. But if the research involves movement into some uncharted scientific waters, then it may not be possible to know whether one is on course or not. In such situations ability to detect deviations early is low and one may have to rely on intuition.

4.915 In R&D work, the nature of research should be identified clearly. Most of research carried out in RDIs in the region is of an applied nature. However, even in applied research there are varying amounts of original scientific inventions and discoveries to be made. In other words, we can think of R&D as forming a broad spectrum ranging from work that is very close to basic scientific research to that which involves little more than the development of a prototype, the scientific details of which are well known. Ability to identify deviations in time is low in the first situation and high in the second.

Where does your own RDI fall in this continuum?

Availability of Corrective Action

4.916 It is one thing to identify the deviations and yet another one to devise corrective action. Whether or not corrective action is feasible, we should always try to identify the deviations. Even when corrective action is not available we can carry out a "damage assessment test" if we know the magnitude of the deviation.

With reference to a project which you know has gone wrong, give some of the items which might be included in "damage assessment":

____

____

____

____

____

____

____

4.917 In a sense, much R&D work is always an exercise in looking for corrective action. At any one time, there will be a number of problems for which no solution has been found. An applied scientist's challenge is to identify as many solutions (corrective actions) as possible. Indeed the reputation of a RDI hinges on success on this front. Inability to find a corrective solution to any one specific problem should not however be treated negatively. Science usually advances by small steps.

A possible way of doing this is through "morphological analysis".

Bibliography

Anthony, R. M. , Dearden, J. and Vancil, R.F.S., **Management Control Systems**, Richard D. Irwin, Inc. , Homewood, Ill., 1986.

Drucker, P. , "Controls, Control and Management", Chapter 31, In **An Introductory View of Management,** New York: Harper & Row, 1979.

Hardingham, R.P., "A Simple Model Approach To Multi-Project Monitoring", **R&D Management**, Vol. 1, No. 1, October 1970.

King, L.T. , **Problem Solving in a Project Environment**, John Wiley & Sons, Inc., New York, 1981.

Liberatore, Matthew J., "An Incremental Approach for R&D Project Planning and Budgeting", **Research Management**, Vol. 24, No. 2, pp. 17–20, March 1981.

"Making Project Management Easy", **Datamation**, April 1978.

Murelins, Olof, **An Institutional Approach to Project Analysis in Developing Countries**, Paris: Development Centre of the Organization for Economic Cooperation and Development, 1981.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER IV

PART II

Technical Performance

TECHNICAL PERFORMANCE

Training Objectives

By the end of this chapter the participant will be able to:

1. Define technical performance.
2. Describe aspects of technical performance which are monitored and evaluated.
3. Identify who is responsible for monitoring and evaluation.
4. Apply selected methods of technical performance monitoring and evaluation.

Technical Performance

Contents

With prior reading, this material can be covered in one session.

CHAPTER IV

PART II

TECHNICAL PERFORMANCE

5.111 In this part of the manual, we shall look closely at one of the aspects of performances assessment, viz., technical performance. We have chosen to start our discussion with technical performance because, at the end of the day, this is what R&D work is all about. It is due to technical work that R&D results can be seen most vividly. While other aspects are also important, this is the one area which can make the difference between an outstanding RDI and one which is not so good.

Do you agree with this observation? Explain why or why not.

5.112 In this discussion, we shall be concerned with various techniques which are available for assessing the technical performance of R&D projects. We shall also be concerned with how these techniques can be applied in real life.

5.113 Before we go too far, let us state the role of technical performance again. Technical performance is concerned with ensuring that the various tasks in an RDI project are done in the most scientifically correct manner so that the objectives of the project may be achieved in the most efficient and/or effective manner. The search for the most technically or scientifically suitable method is a central concern in the technical performance of a job. This being the case, we may appreciate the need for monitoring and controlling technical performance of a given project.

Reasons for Monitoring Research Projects

5.211 There are several reasons why we should be interested in monitoring the technical performance by a project. These are:

(a) We monitor in order to ensure that the research in question adheres to the objectives for which the project was set up in the first place.

(b) Monitoring is important since it addresses itself to the important matter of efficiency ensuring that inputs and outputs of a project are properly balanced and that duplication of efforts is avoided.

(c) Monitoring allows us to modify research methods and to apply new methods or new approaches as knowledge becomes available.

(d) Proper monitoring may allow the research staff to anticipate the effects of social, political and economic forces on a given project — e.g. impending currency devaluation, changing political alignments, changing social values, etc.

(e) Monitoring ensures that information on research progress in other institutions or other countries is available at the earliest possible point in time.

(f) Finally, due to the uncertain outcome of research efforts, it is necessary to ensure that monitoring is carried out regularly.

5.212 An underlying issue in monitoring is to ensure that there is proper resource utilization — i.e. that the project is being carried out in a cost effective manner. This will become evident when we get to the part which deals with assessing cost performance.

5.213 Technical performance evaluation is, however, not without problems. There are some people who object to having their work evaluated since they believe that they are being criticized and they therefore resent any such moves. In some cases it may, in fact, be impossible to do a proper evaluation and this is so in those cases where the research work is of a creative nature or where there is no clear linkage between current research efforts and ultimate benefits to society — this is mostly in pure research. Some scientists also feel, rightly or wrongly, that they are most productive when they are left to themselves. Whether this is true or not is perhaps a matter for research!

Is this a common experience in your RDI? Do you readily accept evaluation of your work?

Aspects to be Monitored/Controlled

5.311 The next question which arises is : What aspects of a project are monitored and controlled and what parameters do we look at ? Table 5.1 below summarizes those we consider to be significant.

Table 5.1

Aspects Monitored/Controlled	Parameters/Means
1. Continuing project relevance	Project evaluation
2. Staff competence	Task performance Quality of work Timeliness
3. Progress towards objectives	Progress reports Periodic reporting
4. Quality of experiments, research design, data gathering, data analysis and reporting	Project reviews Progress reports Evaluation Seminar Annual reports
5. Utilization of facilities and supplies	Progress reports Cost reports Annual Reports
6. Cost effectiveness	Cost/benefit ratio Variance analysis
7. External linkages	Interviews Peer reports
8. Communication of results	Scientific publications Conference proceedings Seminars Progress reports
9. Technical integrity	Research replication Verification of results Peer reviews

5.312 These are illustrations of aspects which can be monitored and/or can be specified for a given research project. The reader is invited to suggest a few others and to state the manner in which the evaluation can be done.

We should add that reporting is such a critical function that it is the hallmark of good management projects.

5.313 From the foregoing, it is apparent that reporting of one type or another is an important means of letting others know what is going on within their individual projects. A good report will, in addition to informing superiors and peers of progress to-date, also act as a means of inculcating self-discipline to the scientist because such reporting forces him to consciously think about what he has done so far, what he has achieved and what still needs to be done.

5.314 Since reporting is critical as a means of letting the superiors know what is going on, it also follows that once the scientist has reported on his work, his seniors should give some feedback on that report. It should indicate the principal strengths and weaknesses; point out areas requiring further work or analysis; suggest ways and means of improving on the methodology being used and so on. If a scientist is doing a good job, the supervisor should not feel shy about telling him as much — no one really hates being told he is doing a good job, especially if he, too, believes that he has done a good job. It is what psychologists call positive reinforcement, it is an incentive system.

Two way process. Do your superiors always give you feed-back on your performance?

How many times do you recall being told by your supervisor that you are doing a good job? How about you telling your subordinates that they have done a good job?

5.315 A good report should, in addition to saying what has already been achieved, give a summary of the work to be done before the next reporting date and should also give a date when such a report is to be produced. Such a commitment, in writing, forces the scientist to direct all his attention towards achieving the target date. Unfortunately, without active follow-up and some insistence about meeting scheduled reporting guidelines, most people tend to let things drift in the hope that "someone up there" has forgotten or that the problem will somehow go away. While someone up there could very well forget due to pressure of work and other more urgent commitments, the problem does not go away — invariably, it tends to get worse and hence requires even more control!

5.316 Despite the above and other arguments, monitoring (and control) of R&D technical work is a desirable activity. We should recognize that most RDIs are mandated to achieve certain specific objectives. It may be finding a cure for a disease or range of diseases; it may be to develop a new and improved crop or animal variety. It is in this respect that work done in RDIs differs from work done in universities where the main objective is to extend the frontiers of scientific knowledge.

What are the principal differences between RDI research work and university research?

____

____

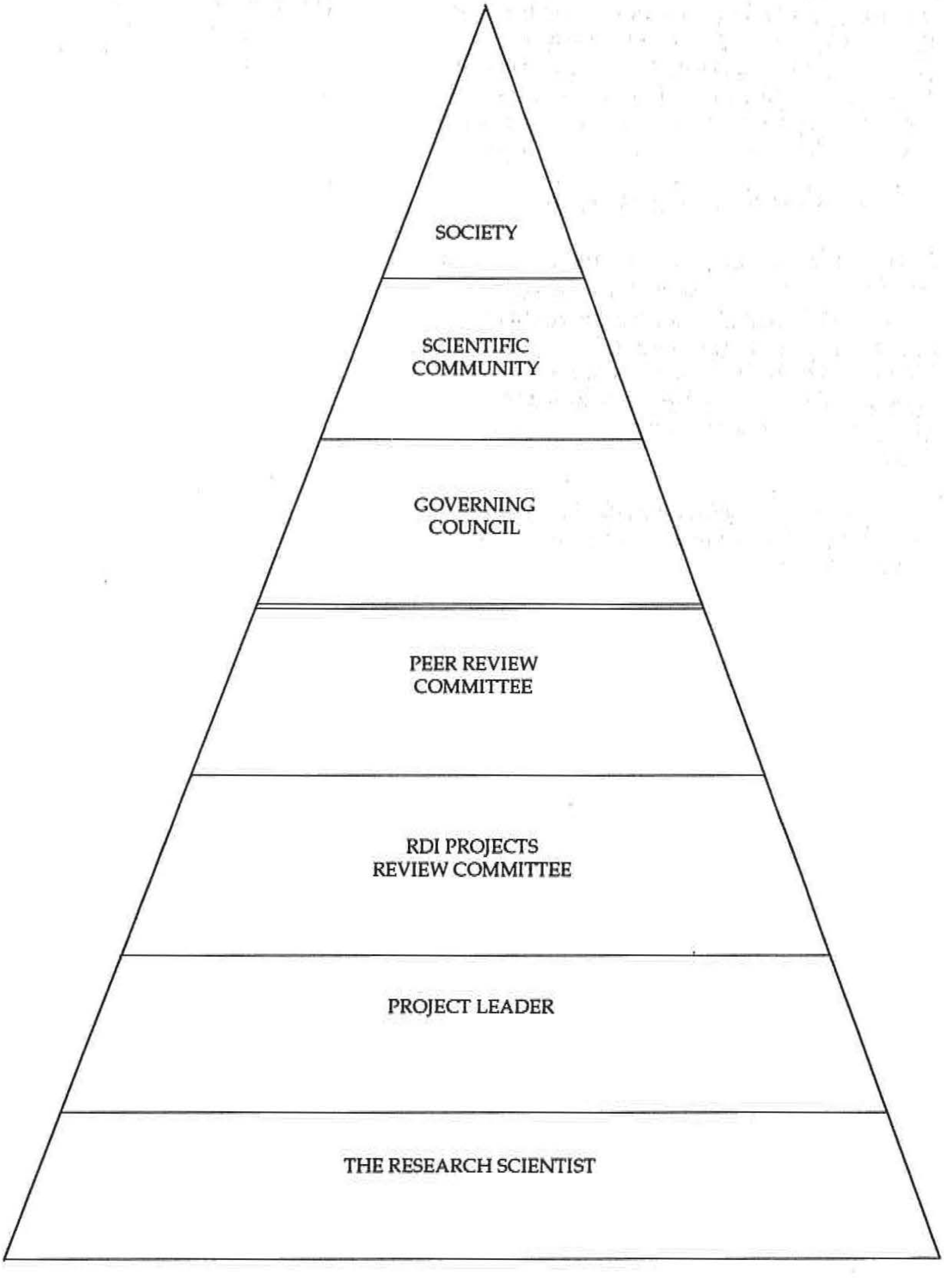
____

Monitoring and Evaluating Hierarchy

5.411 Having agreed that monitoring technical performance is desirable, who should do the monitoring ? Clearly, whoever does it must himself be technically competent. It would be impractical to ask a person who does not understand the technical aspects of a job to monitor it, leave alone asking him or her to evaluate it.

5.412 It may be useful to think of technical monitors forming a hierarchical structure as depicted in Figure 5.1:

Figure 5.1. Hierarchy of Monitors



The Researcher

5.413a This is the individual scientist (or team of scientists) who actually carries out or supervises the various technical aspects of a given research project. He is intimately familiar with all the technical details concerning the project. Clearly, then, he is in a special position to monitor technical progress and later evaluate the information resulting from it. His data will initially be recorded in field/laboratory notes and routinely or regularly summarized in internal reports to a higher authority — e.g. project leader or programme head. These periodic progress reports include information on technical progress, time spent and costs incurred based on the original workplan. Some institutions may require financial and/or administrative reporting more frequently. On an annual basis, researchers must present a research report incorporating aspects of technical achievement and time and cost spent in achieving the results.

In your own RDI what are the details to be included in a scientific report?

5.413b The research scientist is ultimately responsible for the successful completion of his part of the project and this is a duty he cannot delegate or avoid. However, the successful performance of his own job is not sufficient if he does not report to a higher authority what he has done. This is a management responsibility. Jointly, the two constitute effective project management.

Project Leader

5.414 In many R&D projects, a team will be working on a project. This team is usually under the general supervision of one individual whom we shall call the project leader. The project leader may or may not be directly in charge of a specific aspect of the project. But it is his overall responsibility to coordinate the efforts of the team of scientists, etc. He will have general familiarity with all the specific tasks. He, perhaps, will be the first to read the internal reports prepared by the specific scientist. Since he is in charge of a number of interrelated aspects of the project, he will be in a unique position to determine which particular technical aspect is out of control or is headed in that direction.

How does the project leader keep in touch with the work being done by his staff in your RDI?

RDI Project Review Committee

5.415 This is a technical committee which deals with all the technical aspects of the RDI's work. Its major responsibility is to ensure that the technical standards of the RDI are up-to-date and that they are being adhered to. It is common for this committee to review the technical progress of each project at least twice a year. The review is usually thorough and very detailed. The recommendation of this committee determines whether or not continued funding will be available. It is important at this stage to distinguish between the existence of an actual committee and the existence of this function. In some RDIs, there might be no committee as such but the director of the institute may in fact be performing the duties of this committee. It is more preferable, however, that a committee be available. It is also mandatory that the committee be made up of technically qualified people even if it is in different aspects of the project. They are the only ones who are capable of evaluating the performance of a research project from a technical perspective.

In your own RDI, how is this function discharged?

____
____
____
____

If you have a committee, how frequently does it meet?

____
____
____
____

In general, do you feel that such a committee is a good thing? Explain either way:

____
____
____
____

Policy Body of RDI

5.416a The next level of evaluation is that of the policy making body of the RDI. This could be the governing council or some other such named body. It will consist of those people who are appointed to interpret the mandate of the RDI and whose responsibility it is to approve research projects carried out in the RDI.

5.416b Their review, however, is of a strategic nature. They will be concerned with determining whether or not the work being done is consistent with institutional mandate and whether the fit between projects and programmes is acceptable. They will sometimes rely on recommendations made by the Project Review Committee of the RDI in which one or more of them might even be represented.

In many cases, they do not have a choice. The alternative is for them to appoint their own technical sub-committee — perhaps an unnecessary duplication

5.416c Their level of analysis will take into account the broad guidelines within which the RDI is expected to operate reflecting, as it were, government priorities and allocations of funds. The extent to which they will be able to procure funds and other resources might very well depend on how they execute the mandate of the RDI.

Peer Review Committee

5.417a This is less common than the above three arrangements. A peer review refers to a group of R&D team, preferably from another RDI (of repute) who are invited periodically (say, once every three years) to review the technical performance of the RDI. Usually, the team will be made up of highly reputable scientists who have established themselves as leaders in the areas of research in which the RDI is engaged. Their report, which is usually addressed to a level above the RDI is valuable in deciding whether or not the RDI is contributing to national development. A peer review will, of course, evaluate the entire RDI and not only the technical performance aspects of a selected number of projects.

Does your RDI have peer reviews? If so,

(a) how often do they meet?
(b) What do they do?
(c) Who do they report to?
(d) Are their reports circulated internally
(e) What is their composition?

5.417b In addition to an external peer review committee, many RDIs also have internal peer reviews. This may consist of a selection of the more senior research staff who will be given mandate to assess the technical performance of the projects being carried out in the RDI. Their job requires that they be objective in their assessment and to bear in mind the limitations — technical, material, personnel, financial — facing those whom they are evaluating. Knowing them fairly well and being aware of the position of the RDI itself, they will be more understanding and sympathetic than outsiders. It is only the larger RDIs which can afford to have internal peer reviews. In the smaller ones, objectivity may be impossible to achieve.

Do you have internal peer reviews? If no, why not?

5.417c A peer review should not always be regarded as a good thing. Where the country is engaged in top secret scientific research, it would be plainly naive to invite a peer review. That, perhaps, is the case in microchip technology or genetic engineering research. However, most of the activities of RDIs in our region have more modest objectives and a peer review might do some good. Classified research should be kept out of reach of the members of the peer review team if this is considered desirable.

5.417d In peer reviews there should be concern with other aspects of the scientist's work. Some of these are of a non-technical nature and include, for instance, contribution to extension work, successful communication of results, ability to work well with farmers, agents, social workers and other researchers. This is especially the case with work done with field applications.

What weight, if any, is given to these matters in your own RDI?

Methods of Monitoring Technical Performance

Reporting

5.511 Reporting on various matters affecting the progress of a continuing project is one of the most important functions of project management. Yet, we find hardly any mention of the importance of reporting in the most standard books on management. This, we think, is a very serious omission because experience has shown that when reporting is neglected, then things can go so seriously out of control that it will take a long time and a lot of effort and resources to bring the system back into control. In some cases, things may have got so bad that there may be no solution to the problem at all. We would therefore like to reiterate that in project management, the matter of report preparation and submission must be given top priority. It is the only formal way by which the higher authorities can be kept informed of what is going on in the project. A written report serves as permanent documentary evidence of what was happening in the project.

See whether you can find evidence to the contrary in any standard text book.

What priority appears to be given to this matter in your RDI?

5.512 Reporting is necessary whenever the management of the project is unable to be directly involved in constant supervision of the project personnel. Since they have no other formal way of knowing what is going on, then a report becomes the surrogate for physical presence.

What is a surrogate?

5.513 Reports are of two principal types:

- Written reports

- Verbal reports

Both are part of what forms the formal structure of organizational management.

For a report to be effective, it is critical that there be at least two related matters :

- Acknowledgement of receipt of the report. This simply means that the reporting unit gets formal recognition that the report has been received by the higher authority. This obviously only applies in the case of written reports.

How do your superiors rate on this matter? How about yourself?

- Feedback:
  It is not enough for receipt to be acknowledged. The receiver, being the relevant authority, must make a point of providing some feedback to the writer. This feedback could be by way of suggesting improvements or suggestions for the next stage. It could also be simply commending the scientist on the good work that he is doing and assuring him of continuing support.

Define "feedback":

____
____
____
____
____

5.514 Our view is that far too many superiors tend to ignore this important aspect of feedback. It is a mistake and for effective management of RDI projects, it must never be allowed to happen. At the very least, lack of feedback gives the scientist the impression that nobody (at the top) really cares about his/her work.

Do you agree with us or not? Give illustrations.

5.515 Feedback should be promptly, or at least, speedily given. It will not do much good for your boss to acknowledge several weeks or months after the report is submitted. This is especially the case where continuation to the next stage depends on successful or acceptable completion of an earlier stage.

How long does it take to receive feedback (especially negative feedback)?

Written Reports

5.516 While we need not get into elaborate detail about report writing, there are several important points to take into account in every written report.

Addressee

5.517 The report must be addressed to a specific person within the organization. This could be the RDI head or it could be the project leader. We have noticed two basic approaches in addressing the report.

5.518a In the first case, the report is addressed to the RDI director through the project head or through the programme head. The objective in this case is to ensure that the immediately higher levels of the organization are also informed of the scientist's work. They will be required to endorse the report to indicate that they have at least seen it, if not, as would be preferred, read and understood the contents. By making such an endorsement, they have, at least, tacit responsibility for the contents.

5.518b Such an endorsement should not be made lightly. We know of cases where some departmental or project heads initial a report without even looking at the contents. Perhaps the following story which we gathered in the course of collecting material for this manual can help bring the point home.

Illustration

5.519a In one Eastern African country, the government had become quite concerned about the size of the bureaucracy in one parastatal. It was accordingly decided to trim down the work force by weeding out all the "dead wood". The managing director was sent a letter from the ministerial headquarters asking him to submit a list of people to be terminated. He asked his personnel manager to attend to the matter and to submit the requisite list.

5.519b The personnel manager, with the assistance of departmental heads, went through the exercise and prepared the necessary covering letter to the ministry for signature by the managing director. As was his usual practice, the managing director signed the letter without checking the contents of the full report.

5.519c Several days later, he received a call from the ministry asking him to confirm verbally that the letter had been signed by him and this he did at once with some vigour. After about a month, he received a letter from the ministry commending him for his forthrightness in suggesting who should be retired since they were "dead wood" and asking him to make the necessary arrangements to hand over the management to a younger person they were sending over.

5.519d Alarmed, he called the ministry to ask why he had been retired. He was told to check the list he had submitted to the ministry. Right there, at the top of the list, was his own name !

5.520 An alternative method to writing through the head is to write to the relevant authority and copy it to the intervening heads. It can also be written to the head and copied to the higher authorities. Either way, the objective is to inform the recipient that he is not the only one who has received it. It increases the chances of early action.

Report Format

5.521 The written report should be written in simple and easily understandable language. It must be brief and precise while addressing itself to all those matters necessary or effectively communicating to the higher authority the status of the project. The extent of complexity will depend on the subject matter and the training of the addressee.

5.522 The report will generally include the following salient points :

- Purpose. A sentence or two will explain the reason behind writing the report.
- Circulation. This gives the number of people to whom the report has been circulated.
- Period. This shows the period covered by the report. It should start with the date of the last report and end with the expected date of the next report.
- Contents. The contents will vary according to need but will state:

- **Achievements of the last report (briefly)**
- **Achievements since the last report**
- **Problems, if any, encountered**
- **Resource utilization for period under review**
- **Actions required by the higher authority to allow project continuation.**

- Summary and conclusions. Sometimes the summary and conclusions may be placed at the beginning of the report. This is normally for the benefit of the busy executive who does not have the time to read all the details.

Exercise: As an exercise, take a recent report from your RDI. Analyse it to see if it covers all the points mentioned in this section. Would you say it was a good or poor report? Explain.

Frequency of Reporting

5.523 How frequently reports should be submitted is a matter for the RDI management to determine after having due regard to the nature of the project. Some projects may require weekly reporting, others may only require quarterly reports. There are no hard and fast rules. However, we must state in no uncertain terms that there must be specific reporting points if project management is to be successful. To fail to do this, especially where there is no day-to-day supervision is to miss a very important control

What is your RDI's policy regarding frequency of reporting?

factor. This is especially the case with subcontracted projects or parts of a project. For most RDI projects, quarterly reports have been found to be adequate.

5.524 For higher levels of the organization, annual reporting should be adequate. Terminal reports are expected at the completion of a project and in this report the various items to be reported upon will include:

Technical:

- **Abstract of the detailed report**
- **Research methods used**
- **Results and discussion of these results**
- **Conclusions**
- **Shortcomings or limitations**
- **Recommendations for future investigation**
- **References**
- **(Sometimes) a list of publications from the research**

Does this look familiar? If not, you may have a problem.

Financial and Managerial:

- **Resources used up**
- **Costs expended**
- **Time taken**
- **Significant problems encountered.**

Flow of Monitoring Reports

5.525 We now summarize the flow of project monitoring reports highlighting the various reporting entities. It should be noted that as one moves up the organizational ladder, the reports become shorter in length, less technical and less frequent.

MONITORING REPORTS

	Author	Report Type	Addressee
1.	Research Scientist	Periodic progress report including financial and material usage. Annual and Final Research report	Project Leader Section Head
2.	Project Leader	Summary of Project progress reports. Annual summary of projects under his control	Programme Leader
3.	Programme	Summary of programme progress reports. Annual programme meetings — minutes and final report	Research Director
4.	Station	Summary of station research projects. Summary of costs, materials, achievements (Annual Report)	RDI Management (Director)
5.	RDI Director	Annual Report as in Station Head	Council of RDI or Government Department

Verbal (Oral) Reports

5.611 In addition to, but never in place of written reports, there ought to be verbal briefings by the research scientists to their project or section heads. The objective is the same as in the case of written reports, namely, to keep the respective higher authorities informed of prospects, problems, costs, etc.

What other good does a report do to the people involved?

5.612 Verbal reports can be:

- Ad hoc. These come about during the visits, unprogrammed meetings, casual consultations, etc.
- Formal. When progress review meetings are scheduled in advance and an agenda is prepared to aid in discussion, then the reporting is said to be formal. Minutes are kept of the discussions.

5.613 In either case, it is recommended that a brief report be written afterwards to confirm, if nothing else, that there was a meeting and that certain matters were discussed. Experience has shown that people may sometimes make claims or make promises orally which they refuse to honour later since, as it usually goes, "there was nothing in

What is the use of such a report?

writing". Such a write-up also acts as a good "aide memoire" — something to assist in remembering what was discussed.

5.614 It is recommended that such a follow-up write up be done as soon as possible after the end of the meeting. People tend to forget rather easily!

Types of Oral Presentation

5.615 In addition to verbal reporting, one can also talk of higher level oral presentations. These include seminars and conferences where progress on ongoing research is reported upon. Some can be quite informal — e.g. staff seminars — while others require a lot of advance preparation and may involve considerable cost — e.g. conferences.

5.616 During oral presentations, the researchers will present to their colleagues their progress, findings, problems, prospects and so on. In such meetings, a critical (not hostile) approach should be adopted especially if people are from the same RDI. Nothing should be taken as sacred or sacrosanct — scientific progress rarely proceeds on the basis of accepting the status quo without question. It is also possible for such meetings to degenerate into what one person referred to as "mutual admiration societies". This must be avoided.

It is not always easy to tell the difference between criticism and hostility!

Why is this necessary?

Advantages of Oral Presentations

5.617 An oral report also involves a wider audience than a written one. This can give considerable variety of opinion and this could be a good thing.

5.618 Properly done, oral presentations will force scientists to <u>think ahead</u> since they may be called upon to answer relatively difficult questions or to justify positions or methods used. They will therefore be placed in a situation where they have to anticipate such questions. This is a positive attribute in scientific research.

5.619 Similarly, if it is properly done, it can motivate scientists to higher levels of personal achievement since they know that their peers will be there to judge them and their work.

A properly executed piece of research whose progress or results are given in a seminar may do more to enhance a scientist's reputation than several written papers.

Do you agree? What is your own view of this?

5.620 As in the case of verbal reports on on-going projects, there should be some form of permanent documentation for conference or seminar presentations. For seminars, the minutes of the seminar may be sufficient — with adequate circulation. For conferences, the standard method is conference proceedings.

A Final Word

5.711 As a final caution on assessing technical performance, we note that this is an exercise that should be done by technically competent people. Only those people who fully understand the state-of-the-art in the particular field ought to be involved. A lot of time and effort can be wasted trying to educate non-experts who wish to show that they are also knowledgeable. This is so much so in the case of sectional heads who may not be (neither are they expected to be) proficient in all aspects of the research being carried out in their respective sections. Nothing is more creditworthy in scientific enquiry than for a person to sincerely admit that they do not understand a particular subject than to insist on getting explanations on what is elementary to those who are more familiar with the subject matter.

We suggest that you may have come across this type of person in your years of research work!

5.712 This does not mean, however, that a scientist should be allowed to get away with questionable work just because no one else understands what he is doing. A proper balance between the two can be reached with experience.

Bibliography

Archibald, R.D. and Villoria R.L., **Network-based Management Systems (PERT/CPM),** John Wiley & Sons, Inc., New York, 1967.

Cleland, D.I. and King, W.R. , **Systems Analysis and Project Management**, McGraw-Hill International Editions, London, 1987.

Eisner, H., "A Generalized Network Approach to the Planning and Scheduling of a Research Project", **Operations Research**, Vol. 10, No.1 January–February, 1962, pp.115–125.

Hill, L.S., **Towards An Improved Basis of Estimating and Controlling R&D Tasks**, The Rand Corporation, Santa Monica, California, May 1966.

Robertson, D.C., **Project Planning and Control: Simplified Critical Path Analysis**, London: Heywood Books, 1967.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER IV

PART III

Schedule Performance

Schedule Performance

Training Objectives

By the end of this chapter, the participant will be able to:

1. Define schedule performance.
2. Specify techniques for monitoring and controlling schedule performance.
3. State the major strengths and weaknesses of these scheduling techniques.
4. Determine where application of these techniques would be most appropriate.

Schedule Performance

Contents

The material in this part can be covered in two to three sessions depending on the detail one wishes to get into. Prior reading is mandatory.

CHAPTER IV

PART III

SCHEDULE PERFORMANCE

6.111 As was mentioned in the previous part, performance evaluation takes on many forms. Technical performance of a project was the subject matter of the previous section. Schedule performance will be discussed in some detail in this section of the Manual.

6.112 We must however, remind the reader not to take the breakdown of evaluation into various types too rigidly. The breakdown is largely for pedagogical purposes because, in real life, the evaluator looks at the project as a totality. It is when it comes to specific aspects of a project that the use of a particular technique may become necessary.

6.113 It should also be noted that in a manual of this type, it is not possible to give the reader all the information he requires in order to apply a particular technique. Our main objective is to alert the user about the existence of these techniques and not to make him an expert in their application. Whole books in project management have been written about some of these techniques; some of these have been suggested at the end of this Manual for the astute reader. We encourage those who are so inclined to delve deeper into some of these techniques.

Definition

6.211 Schedule performance refers to the exent to which a given project has stayed within the time allocated to it. It deals with tasks to be performed towards the completion of the project and the amount of time it has taken to complete those tasks. Completion dates are normally imposed for the various tasks and it is the intention in schedule performance evaluation to find out if these have been met and, if they have not been met, to find out the causes for such failure.

What is a project task?

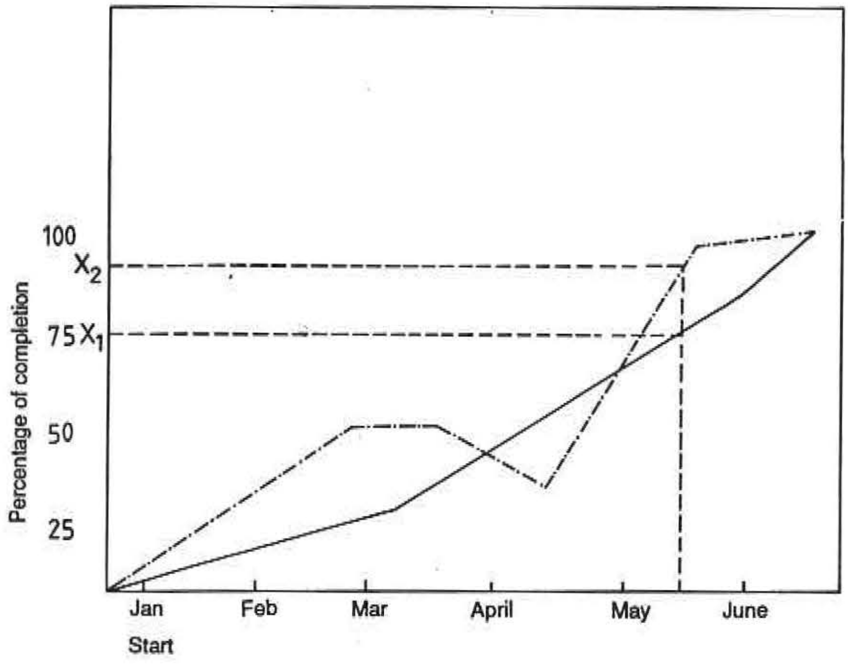
6.212 Schedule performance can take on different forms. One can look at the project in total and ask: How close are we to its completion? In this case, one is referring to both technical completion as well as time completion. The two are interlinked in many ways and separation may neither be possible nor desirable. Alternatively, one may look at specific tasks and ask: How close is this specific task to completion on the assumption that the project is still technically feasible?

6.213 Before we consider specific schedule performance techniques, let us consider several borderline techniques — or hybrid techniques — because they involve both technical and schedule performance.

Rate of Completion Technique

6.311 A common approach used to monitor technical performance is <u>the rate of completion method</u>. It is based on the project team's ability to estimate a rate of completion over the duration of the project. This means that the project staff must be able to identify in a reliable manner what percentage of the technical work will be completed at any given time. This concept may be conveniently illustrated in a graph as shown in Figure 6.1.

Figure 6.1. Planned vs Actual Performance

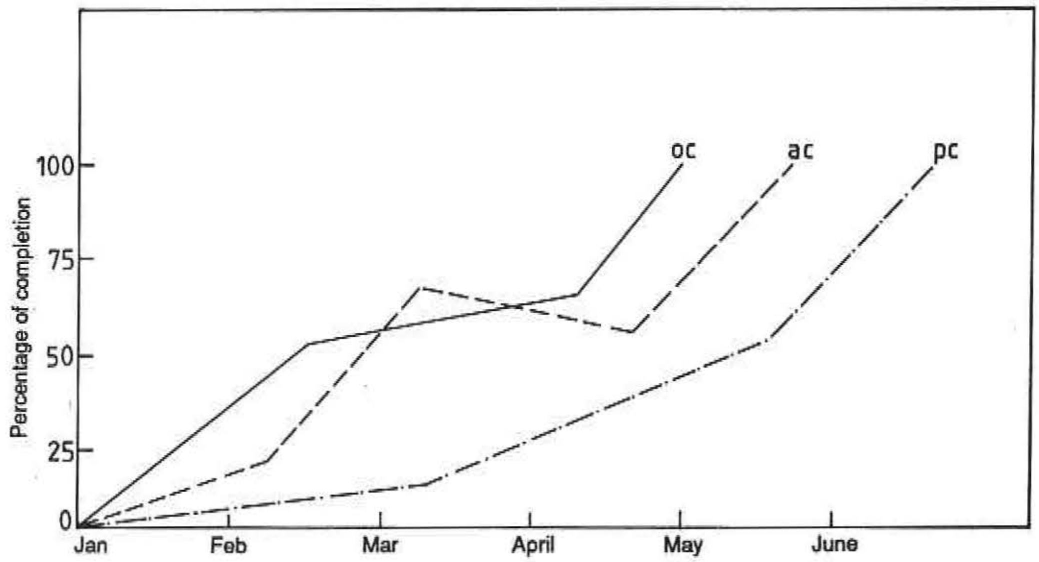


6.312 Note from the graph that this is a six month project. This is obviously over-simplification. Many R&D projects go on for years. Some indeed go on for generations before a solution is identified. In this particular case, we should note that by May, the plan was that 75% (X_1) of the work was supposed to have been completed. Instead, actual performance shows that about 90% (X_2) of the work has been done.

6.313 Over the life of this hypothetical project, though, there were times when actual performance was better than planned performance, for instance, between January and March. There were other times when the actual performance was below the planned performance — e.g. in April. Note also that there were times when performance seems to have been declining — also in April. This represents corrections and revisions that involve dismantling part of what has already been done.

6.314 The percentage of completion technique outlined above is slightly idealistic. A more flexible approach is to determine a performance range within which one is expected to operate. This is illustrated in Figure 6.2.

Figure 6.2. Planned vs Actual Performance: The Range Method



6.315 Assuming the optimistic plan is achieved, the job gets finished at the end of April (oc). If the more pessimistic plan is the one that turns out to be correct then the job will be finished at the end of June (pc). In this particular example, the job gets finished at the end of May (ac) which is well within the acceptance range.

6.316 The basic constraint in using the percentage of completion technique in monitoring R&D work is inability to measure the degree of completion and to relate it to time.

6.317a An obvious problem with the percentage of completion method is that in RDI work, the project may be poorly defined in terms of technical completeness. This is because of the nature of work being carried out. By way of comparison, we could consider the case of a road and compare it with the nematode problem in spinach referred to in an earlier chapter in this manual.

6.317b A road has a beginning and an end. It has specific things to be done and certain costs — clearly defineable — to be incurred. At any stage of the construction, we could take two facets of the completion cycle. We could use the distance fully completed to estimate the degree of completion (we might also add other bits and pieces if materials have all been procured, for instance). We could also use the engineer's certificates of work which has been satisfactorily completed and which therefore is due for payment to give us an independent measure of completion. We could also use the actual costs incurred to-date as a percentage of the total project costs; this would also be an acceptable surrogate but only if cost overruns are not to be allowed.

6.317c The case of the nematodes is more complex. Is the project 50% complete when the parasite has been identified or is it when a non-toxic chemical has been developed? Or is it when it has been established that the chemical will not harm the soil and the ecology associated with spinach? Clearly, an answer is much more difficult to arrive at and it is at this stage that the collective experience of other researchers becomes important. Where a newly graduated scientist is generally unable to estimate the degree of completion of his work, a more experienced researcher may be able to call on his experience to give a more balanced view.

How is completion of projects determined in your RDI?

6.317d It is in cases such as these where team effort or consultation becomes important. A team, presented with all the facts, will be in a much stronger position than an individual to assess the degree of technical completion. If a team cannot be assembled to evaluate the facts the only viable alternative may be to rely on hunches or educated guesses.

Schedule Evaluation Techniques

6.411 As indicated earlier, there are many schedule performance evaluation techniques. Our experience is that many of them will almost definitely not be applicable in RDI work because of the nature of work carried out in the research institutes in the region. We would like therefore to suggest that when the choice in a given situation is between a complex and a simpler method, it is usually preferable to use the simpler method. As one gets more proficient, then the more complex techniques can be learnt and used.

6.412 In this part of the Manual, we shall give brief descriptions of various techniques and also suggest their strengths and weaknesses. Detailed treatments can be found in references at the end of this chapter. The reader is also referred to the FAMESA manual on **Strategic and Project Planning and Budgeting.**

6.413 The technique to be considered under this head are:

- Work Breakdown Structures (WBS) or Task Lists
- Project Planning Charts or Bar (Gantt) Charts
- Network Plans:
  - Precedence Diagrams
  - Critical Path Method (CPM)
  - Programme Evaluation and Review Technique (PERT)
- Line of Balance (LOB).

Work Breakdown Structures (WBS)

6.511 In every R&D project, it is possible, at least conceptually, to determine the work components which together make up the project. These components can be visualized in terms of the discrete tasks which must be accomplished before the whole project is considered done. A basic requirement in WBS is the capability of the project to be broken down into tasks, each task having a time period within which it must be completed and, further, specifying the resources necessary for its execution. All the tasks must be seen in terms of their contribution towards the completion of the project. We must point out that in this type of exercise, each sub-component of the total project can be visualized as a sub-project with its own requirements of time, materials, finances, personnel, etc.

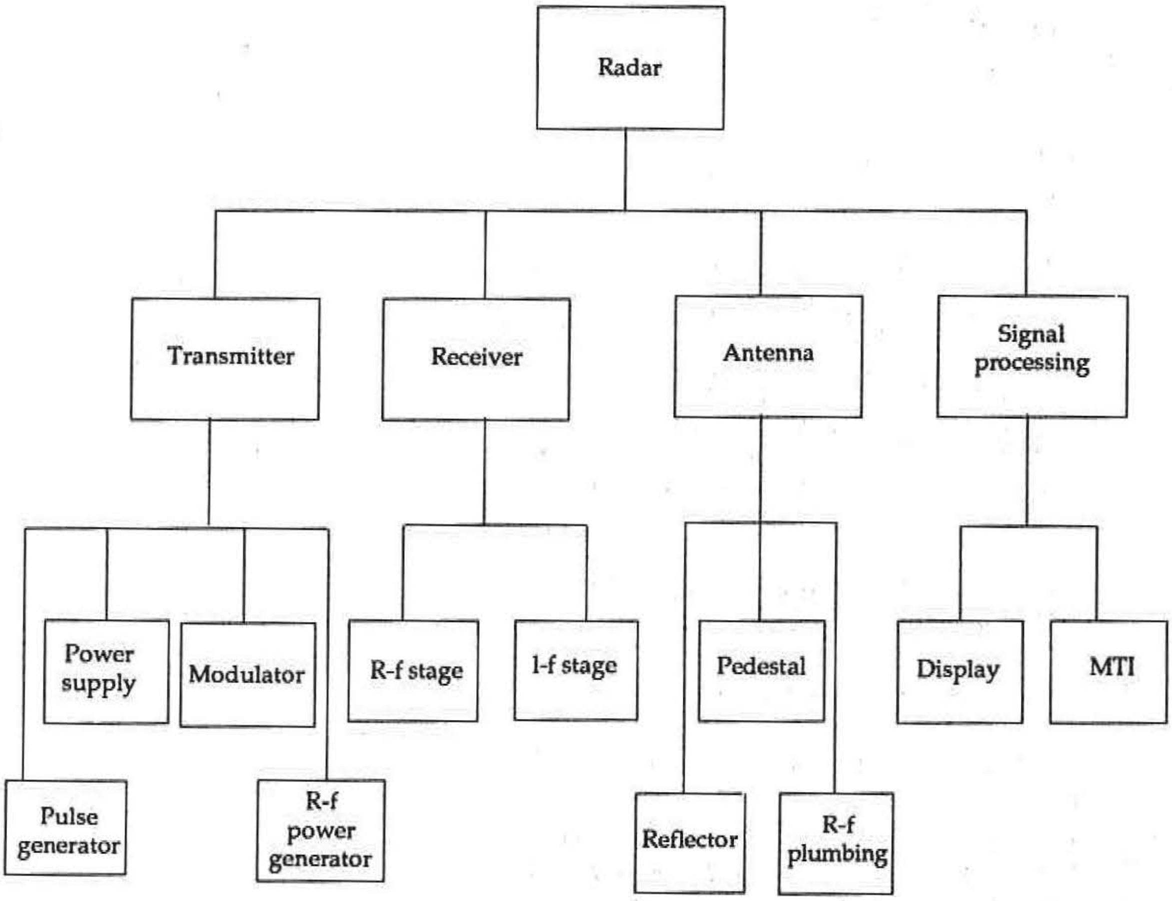
What is a discrete task?

6.512 A work breakdown schedule can be task-oriented or product-oriented. A task-oriented WBS is probably more pertinent to an R&D institute than a product-oriented schedule which is more relevant to a production unit or to prototype

Distinguish a task-oriented structure from a product-oriented structure. Give examples.

development effort. For simplicity, we show below a product-oriented WBS and challenge you, as an exercise, to prepare a similar breakdown for a project in your RDI with which you are familiar.

Figure 6.3. Product Oriented Work Breakdown Structure



Source: Robert W. Miller, **Schedule, Cost and Profit Control with PERT**, McGraw-Hill Book Company, New York, 1963.

Advantages

List others here if you can think of them

6.513 The main advantages of a WBS are:

- It is simple to understand
- It helps in directing effort towards specific tasks or parts of a project
- It enables efficient allocation of duties by identifying the key requirements
- It relates each task to the entire project and thus shows the organizational relationships in a project.

Weaknesses

6.514 Against these advantages there are several weaknesses:

- It has no specific time attachment to it and thus is a poor control device
- It ignores the cost parameters
- It ignores the mutual interaction of tasks, i.e. performing one task may affect how another task will be performed
- It may not be able to take changes into account since it is relatively static.

Project Planning (Bar or Gantt) Charts

6.611 The most widely used of all project planning and scheduling techniques is the Bar or Gantt Chart as it is sometimes called. It is derived and refined from the WBS and takes care of some of the main weaknesses of the former. The principal advantage is that it incorporates time directly into the planning process and by a systematic arrangement of the tasks to be performed, allows the time of completion to be estimated with a fair amount of clarity. With the additional inclusion of optimistic and pessimistic times for the completion of project tasks, it becomes the basis for the more sophisticated techniques like CPM (critical path method) and PERT (project evaluation and review technique).

6.612 In application, the Bar Chart is quite simple. It specifies for each task the length of time required to complete it. The time may be in days, weeks or months depending on the complexity of the project. The procedure for developing a bar chart is as follows:

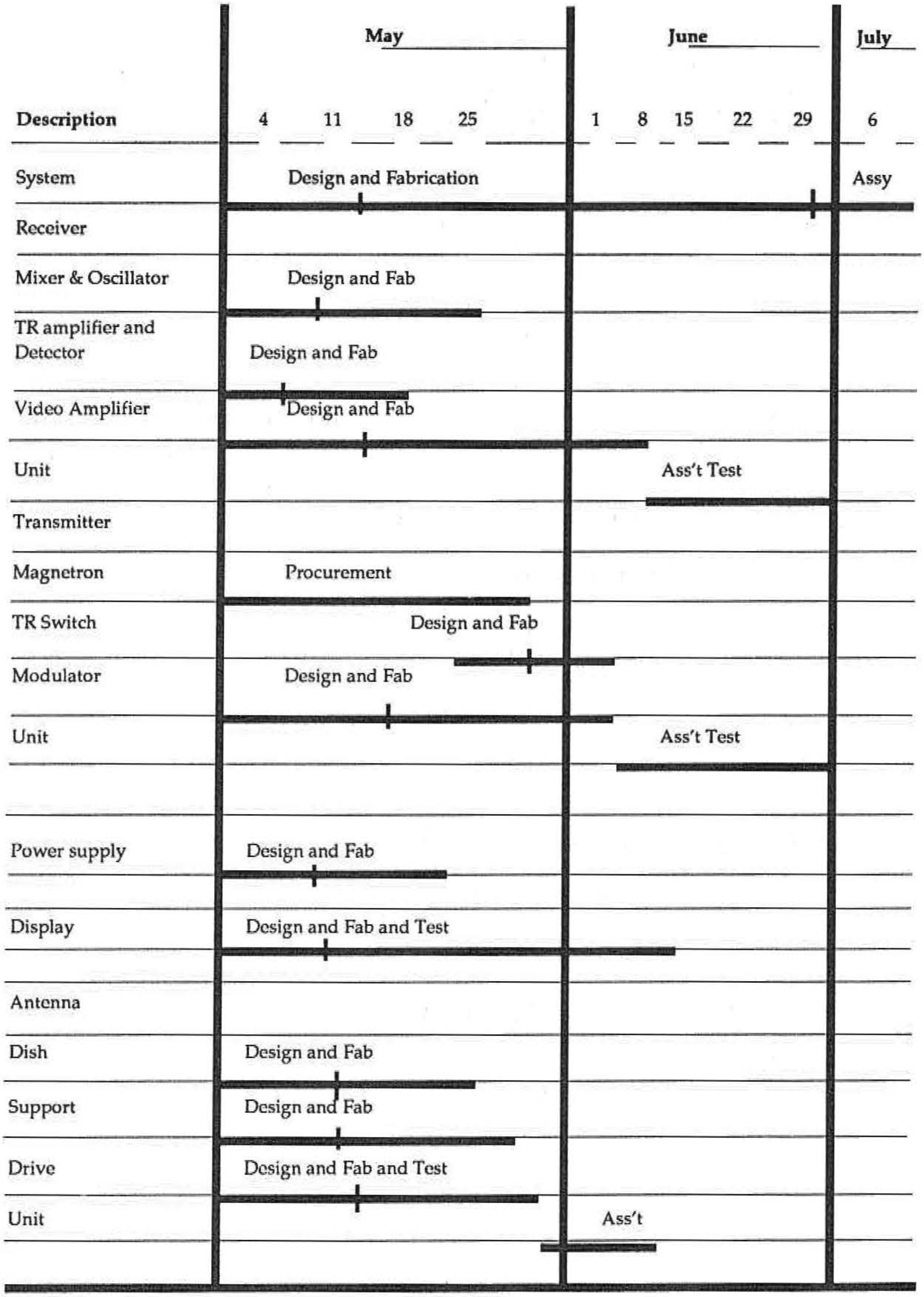
1. Break down the project into the elements or tasks to be scheduled.
2. Estimate (with technical assistance) the time required to perform each element.
3. List the elements on the left hand column of the sheet of paper being used. Specify the proper sequence of those which can be done at the same time.
4. On the horizontal axis (top of the page) write down the months/dates spanning the entire period the project is expected to cover.
5. For each task or element, indicate estimated starting date and the completion date.
6. Connect the two points with a heavy line.
7. Write down the length of time for each task at the end of that task's line.
8. Summing the individual lengths of time will give the total amount of man-days or man-months required to complete the task.

As an exercise, do a bar chart for a project with which you are familiar.

Example of a Gantt Chart

6.613 The figure below shows a Gantt chart for the radar project referred to in the WBS in a simplified version. Note that most of the tasks are performed simultaneously since this is a product-oriented project.

Figure 6.4. Project Planning Chart



Advantages

6.615a As was pointed out earlier, the principal advantage of a Gantt chart is that it combines both tasks and the time required to perform them into one diagram. This enables the researcher or his superior to see easily and clearly the relationships among the tasks and the times required to perform them. It is thus a good planning device.

6.615b Another advantage is that it allows the easy inclusion of actual time consumed once the job has commenced and thus makes it possible to compare actual performance with the planned performance.

6.615c This chart is relatively easy to understand and to construct once the scientist has received minimal training.

Disadvantages

6.616a One of the major disadvantages of a Gantt chart is that it requires considerable expertise on the part of the researcher in breaking down the tasks into discrete units. This is not easy and may require team effort for the tasks to be satisfactorily identified.

How did you find this part of the job when you attempted to do your own Gantt chart?

6.616b Another weakness is that it gives the impression that the tasks are unrelated. In any project, each task is closely related to other concurrent, previous or future tasks. Such relationships are not easy to depict pictorially.

6.616c A Gantt chart does not indicate the requirements for each task. Some tasks may require many more personnel than others due to their complexity; the chart cannot show this.

Why is this a personnel desirable feature in project planning?

6.616d For proper scheduling, a lot more detail is needed than can be given in a Gantt chart. Without such detail, it may not be easy to detect when the project is getting out of control.

6.616e The Gantt chart is a "static" technique. It does not allow the user the chance to consider what would happen if alternative schedules were to be considered.

6.616f Finally, it is only useful for relatively small and simple projects. Large complex projects become almost impossible to depict using Gantt charts.

Some can run for hundreds of pages.

6.616g These limitations notwithstanding, it is our view that Gantt charts can be used in much of the developmental work carried on in the smaller RDIs in the region.

Deliverables Chart

6.711 A "deliverables" chart is a modified Gantt chart, modified only in that it specifies what is to be expected at the end of each task.

6.712 In preparing a deliverables chart the same technique is used as in the Gantt chart. The principal difference is that a marker such as a star * indicates when and where a "deliverable" is to be expected. A deliverable may be a component, a prototype for the final product or just the successful design, testing or contracting of a given item. Along the time scale, the star will be shaded if the deliverable is achieved on schedule or it may be moved forwards or backwards depending on the actual delivery time.

6.713a **Example**

Task **Time (Weeks)**

0 1 2 3 4 5

Planned: Design Toggle

1. Actual (on time) ___________*

2. Actual (early) ________*__

3. Actual (late) ___________ _ _*

6.713b The above illustration shows that the planned time for completing the design of the "toggle" was 3 weeks. In case number 1, the design was completed on time while in case 2 it was completed in about 2 weeks. In the third case, it took 4 weeks to complete the task. While this is an over-simplification, we trust that you have got the gist of the techniques. For each task, an appropriate deliverables "star" will be shown.

6.714 The strength and weaknesses of the deliverables chart are pretty much the same as those of the Gantt chart. This should be obvious since the two are really variants of the same thing. One of the additional difficulties in a chart is that it may not always be easy to define a deliverable leave alone specify the length of time required to produce it. This is the case with most pure research or such experimental research as is carried out in many RDIs in the region. Where applied research or development is carried out, it should be possible to specify "deliverables" points for the various components of work.

What is a deliverable in the case of:
(a) Medical research?
(b) Agricultural research?
(c) Animal research

Network Plans

6.811 In the introductory section above, it was indicated that network plans are of several types. These were identified as:

- **Precedence Diagrams**
- **Critical Path Method (CPM)**
- **Programme Evaluation and Review Technique (PERT)**
- **Graphical Evaluation and Review Technique (GERT)**

6.812 These techniques are quite involved and require, in some cases, considerable facility in mathematical manipulations. Whole books have been written on them and it is obviously not possible for us to discuss them in as much detail as might be expected. Neither is it necessary to do so because, as scientists, researchers are much more concerned about knowing that such and such a problem could be solved using such and such a technique and thereafter seeking expert advice on the actual usage of that technique. Just as a scientist does not need to be an expert in the operation of an X-ray machine (this task being left to the technicians), it is our view that he also does not have to be an expert on CPM, PERT or GERT. It may be sufficient for him to know when to use a

This is a rather controversial view. What is your view about it?

particular method and the circumstances in which it may not be appropriate.

6.813 The discussion below should thus be considered introductory only. Detailed examination can be found, as was pointed out earlier, in the references at the end of this chapter or in the **Strategic and Project Planning and Budgeting** if one wants a quick review.

Definition

6.814 A network plan may be defined as a representation of a project in terms of:

(a) the various elements of a project, and

(b) the relationships among these elements.

It is a pictorial display which considers both the technology and the time requirements in a project and shows how they interact. Both resource availability and the needs of other interrelated projects are considered. A network, as the name implies, considers all parts and attempts to reduce the complex parts into a relatively simple format in which the most critical aspect of the project are clearly seen. In some cases, the objective may be to determine the most critical processes and thus derive a critical path which controls progress of the entire project.

6.815 The determination of the critical aspects of a project allows the proper allocation of resources and at the same time allows the management of the project to pay special attention to those aspects. It is a good aid in planning and execution of projects.

What else does it do?

Precedence Diagram

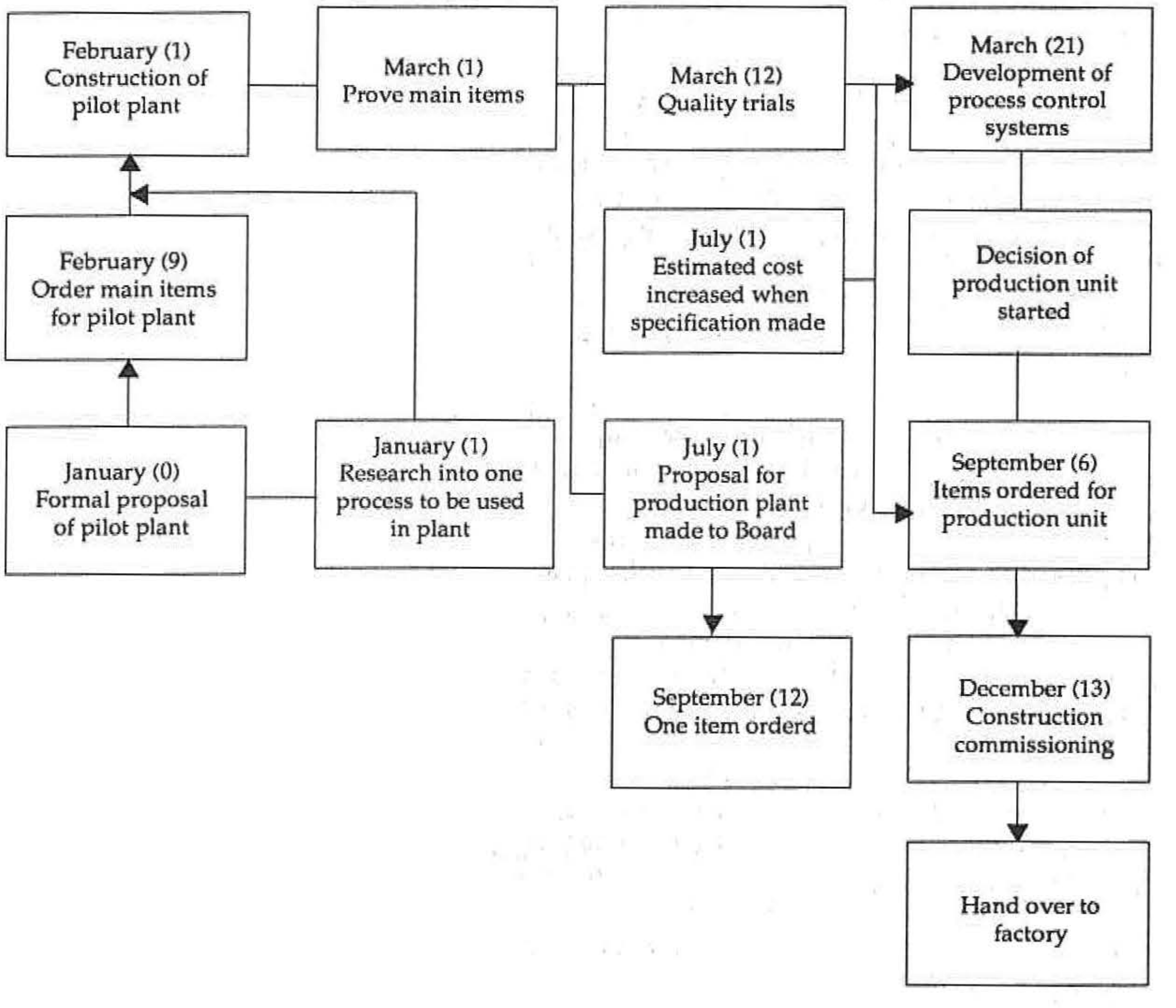
6.816 A precedence diagram is the simplest form of networks. As its name suggests, the steps involved are as follows :

- Identify project elements
- Determine duration of each element

- Map out the relationships among the elements
- Insert expected dates of completion of each element.

6.817 The diagram below shows these relationships for a proposed production plant.

Figure 6.5. Precedence Diagram



Source: A. Wilkes and A.W. Pearson, "Project Management in Research and Development", **British Engineering and Process Techniques**, November 1971, pp. 1009–1011.

6.818 The main advantage of a precedence diagram is that it shows visually what has to be done before the final product is ready. It shows also in their logical sequence the relationships among parts as well as the anticipated dates.

6.819 Against these advantages, one of the major drawbacks of the diagram is the lack of detail. Major tasks are condensed into phrases which are too simplistic to act as a guide to those who need to know what needs to be done. For instance, in Figure 6.5, on March 12, the activity is stated to be "quality trials". This involves a lot of detailed procedures which will require a complete set of instructions. At the operating level, one needs a lot more detail than is given in such a diagram.

Refer to Figure 6.5 and see if this is correct.

CPM and PERT Networks

6.820 In order to simplify this part, we consider both the Critical Path Method (CPM) and Programme Evaluation and Review Technique (PERT) under the same head. The last Technique Graphical Evaluation and Review Technique (GERT) will be considered briefly at the end of this section.

6.821 Both CPM and PERT are much more detailed representations of the general structure contained in a precedence diagram. They are particularly useful in complex projects which require very clear depiction of relationships of time resources and processes well before the project is started. For instance, if one is going to build a laboratory, all the work necessary must be mapped out <u>before</u> the start of construction work.

6.822 Similarly, if it is intended for an agricultural RDI to discover a cure for tomato blight, then those tasks which must be done <u>before</u> the others, <u>concurrently</u> with others and <u>after</u> the others must be decided upon well in advance of the actual start of the research. We shall have more to say about this later.

6.823 In both CPM and PERT, it is possible to visualize the project as being broken down into three major elements

- Objectives are goals to be accomplished in the course of project execution.

- Activities to be executed in the course of execution must be identified and described clearly. They indicate what needs to be done.

- Milestones are significant points in the project when an important task is accomplished or a particular phase of a project is completed. These are points at which progress review can be done. They are comparable to deliverables mentioned earlier.

Define a milestone in your own words.

6.824 In a network, all aspects of the project must be included — technical and managerial — because they involve time and resources. Managerial or administrative activities may in fact introduce constraints which a straightforward technical consideration may not highlight.

6.825 In any network, there are three types of activities:

Attempt a simple classification into these three levels for a simple project you are familiar with.

- Antecedent activities. Those activities which must be performed before other activities can be performed.

- Concurrent activities. These are those activities which can be performed simultaneously with other activities. In other words, their performance is not in any way directly dependent on the performance of others.

- Subsequent activities. These are activities which can only be performed after other activities have been performed.

6.826 Any two adjacent activities in a network, i.e. on the predecessor-successor continuum, are referred to as sequential activities. Concurrent activities are on the other hand independent activities in as far as they relate to those others in their immediate vicinity.

An Example

6.911 In order to illustrate the use of networks, we give below an example which should be familiar with someone involved in agricultural research. It involves the search for a cure from a new blight which affects tomatoes.

6.912 The first step is to decide what the project would entail. The major activities that it could involve are:

- A literature search to determine what is already known about the causes and cures of tomato blight
- An evaluation of the current state of knowledge to determine if the project has merit and, if so, decide what will have to be done
- Research into the causes of the blight
- Research to find a cure
- A test of the cure to prove that it is effective and non-toxic to humans and domestic animals
- Preparation of a pilot batch for samples
- Evaluation of test sample results
- Commercialization of the cure.

Have we left any significant stage?

6.913 The above steps can be put together into a flow chart as shown in Figure 6.6. The most important aspects of this flow chart is that it clearly identifies the basic tasks that have to be performed.

Figure 6.6. Steps in Developing a Cure for Tomato Blight

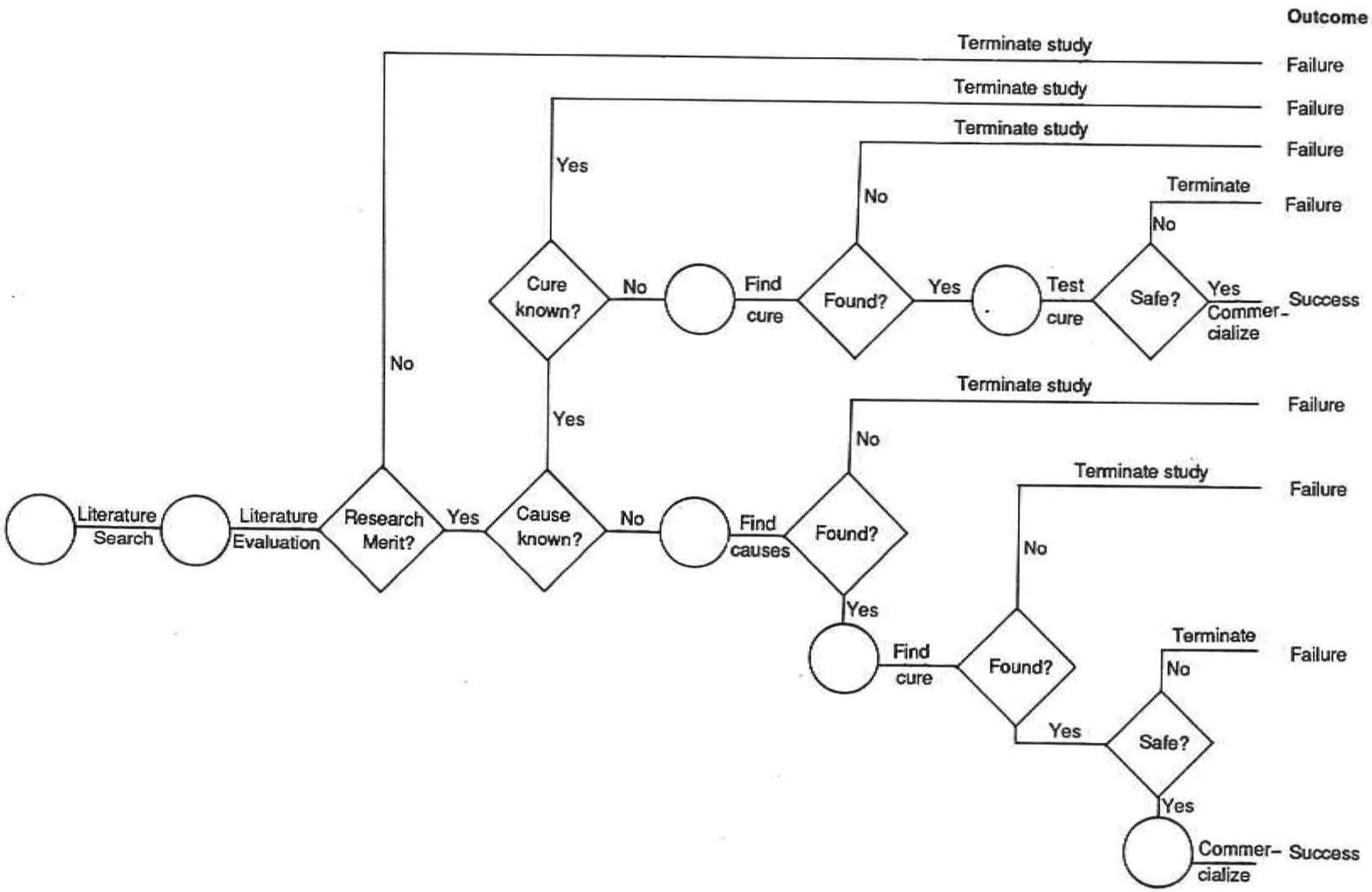
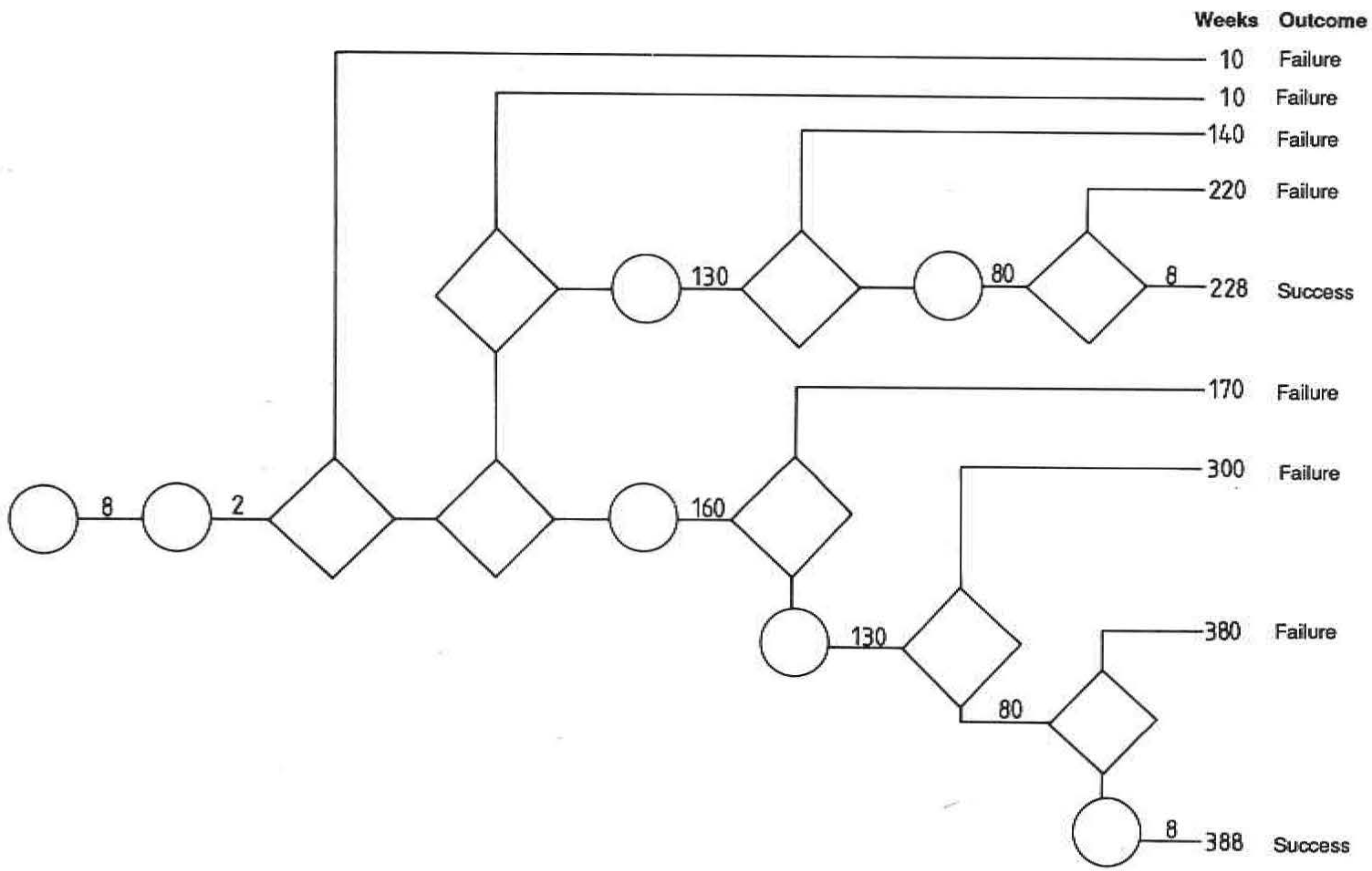


Figure 6.7. Duration of Various Tasks in Producing a Cure for Tomato Blight (Weeks)



6.914 The next logical thing to do would be to estimate how long each task will take to perform. For the sake of this illustration, let us assume the following times:

Activity		**Duration (Weeks)**
Literature search		8
Evaluation of results of search		2
Research to find causes		160
Research to find cure		130
Test cure for safety		80
Making batch for sample		8
	Total	388

6.915 These times can now be inserted into the flow chart as shown in Figure 6.7. From the time-dated flow chart, we are able to identify the following possibilities:

- **Project is abandoned after 10 weeks**
- **Project is abandoned after 140 weeks**
- **Project is abandoned after 170 weeks**
- **Project is abandoned after 220 weeks**
- **Project is successful after 228 weeks**
- **Project is abandoned after 300 weeks**
- **Project is abandoned after 380 weeks**
- **Project is successful after 388 weeks**

6.916 In monitoring schedule performance, we wish to ensure that we live within the scheduled times. For example, in the above hypothetical illustration, research into the cause of tomato blight is scheduled to take 160 weeks. It may however turn out that the required time is much longer than this. This does not necessarily mean that our schedule performance is poor. It is possible that we had underestimated the time required to perform this activity.

6.917 On the other hand, the fact that we are about to complete this activity in less than 160 weeks does not necessarily mean that our schedule performance is very good. It all depends on how accurate the original planned time was. If the planned time had been overestimated, then this performance is not exceptional.

6.918 For the above two reasons, schedule performance should always have two objectives. One, to discover whether the plan is reasonable and two, to discover whether our performance is up to standard.

Can you think of another objective in addition to these two?

6.919 We may discover that an activity cannot be completed within the stipulated time. This does not necessarily mean that the overall project will have to be delayed. It is possible that some other subsequent activity can be performed in less time, thus compensating for the lost time. This is where the flow chart in Figure 6.6 becomes handy. If, for example, we discover that we have taken 140 weeks in finding a cure instead of the planned 130 weeks, we might consider whether the lost time can be recovered when we get to testing for the safety of the cure. Thus, if we can undertake the latter task in 70 weeks, we will be able to complete the project on time. In other words, if the project has to be completed in the originally planned time, time will have to be "borrowed" from somewhere. The borrowing could be done by one of two ways :

As is likely to be the case in a great many projects.

What do you think of this particular suggestion — i.e. reduction in testing time? What risks are involved?

- **Reducing time for some other activity or activities**
- **Increasing resources for subsequent activities so that the time allocated is effectively reduced by use of more personnel.**

Time here is the number of man-days.

6.920 Use of the second approach will necessarily entail more cost and this clearly shows that trade-offs have a financial cost attached. Whether or not the trade-offs will be acceptable will depend on other constraints facing the RDI. Some of these constraints may not be feasible. For instance, it might not be possible to get additional research staff to join the project due to the country's resource limitations. The alternative then may be

What is a trade-off?

Again it will depend on the nature of the project. In an emergency project, cost becomes a secondary issue.

employing an expatriate; this will be both expensive and time-consuming and whether it can be done will, in the final analysis, have to be a value judgement of the RDI director or some other authority.

6.921 The discussion above has tended to take it for granted that RDI projects are of the specific and visible "start-end" type — i.e that the project has a clear beginning, a clear end and it also is discrete. In many situations, this is never the case. In fact, many on-going research projects are like crisis solving where the solution of one problem opens up a plethora of new problems or indicates that the next stage can now be undertaken. An end for the project is therefore never really there. In spite of this and to make RDI planning a less "ad-hoc" affair, and to make control a real possibility, an attempt, however vague, will have to be made. The approach taken will be a matter for the director and his staff and will be a challenge that has to be coped with.

6.922 This example has been designed to show how a real type of agricultural research can be planned. No attempt has been made to show the actual critical path but this may be deduced to be the path of the vital activities which are required to complete the project satisfactorily. In this particular case, it could be the whole of the 388 weeks. Can you state why this is the case?

Could it be 160 weeks? Explain.

6.923 Similarly, the points in the diagram denoted by circles and quadrangles show the project review points. It is at these points in the research process where questions can be asked about the progress being made in the research effort.

Graphical Evaluation and Review Technique (GERT)

6.924 PERT as a review technique is referred to by mathematicians as being deterministic. This means that the formulae used do not allow the consideration of probable outcomes. Events are therefore presumed to be known with certainty.

6.925 With GERT, provision is made for probability and, for each event, there is a range of probabilities. The most likely outcome is determined on the basis of calculated "expected values". It can be seen that this is quite a sophisticated technique and its use requires the use of computers. We mention it here for the sake of completeness only.

Line of Balance (LOB)

6.926 This is what a couple of experts have to say about this technique. The line of balance technique is oriented toward the control of production activities. Although it can be used in such developmental projects as those involving the production of prototypes, it emphasizes the extent of which the planned production of a quantity of items is actually being realized. Thus, its utility in project management is limited. However, it is interesting to note that the weaknesses of LOB are generally similar to those of the other project planning and control techniques. It requires the estimation of the "per cent completion" of component parts, and it is more difficult to understand than comparable techniques such as the Gantt chart.

(Cleland & King)

Like GERT, our interest in this technique is largely academic.

Bibliography

Childs, Marshall R., "Does PERT Work for Small Projects?", **Data Processing**, Vol. 4, No. 12, pp. 32–35, December 1962.

Collier, D.W., "Measuring the Performance of R&D Departments", **Research Management**, Vol. 20, No. 2, March 1977, pp. 30–34.

Dunne, E.J., Jr., Ewart, R.F. and Nanney, D.M., "What Happened to PERT?" **Defence Systems Management Review**, Winter, 1976.

Jodka, John, "PERT (Programme Evaluation and Review Technique): A Control Concept Using Computers", **Computers and Automation**, Vol. 11, No. 3 pp. 16–18, March 1962.

King, W.R., "Project Planning Using Network Simulation", **Pittsburg Business Review**, Vol. 38, pp. 1–8, 1968.

Moskowitz, H. and Bullers, W.I., "Modified PERT Versus Practice Assessments of Subjective Probability Distributions", **Organisational Behaviour and Human Performance**, Vol. 24, 1979.

Paige, H.W. "How PERT Cost Helps the General Manager", **Harvard Business Review**, pp. 87–95, November–December 1963.

Pocock, J. W., "PERT as an Analytical Aid for Programming Planning: Its Payoff and Problems", **Operations Research**, Vol. 10, No. 6 pp. 893–903, November–December 1962.

Sadow, R.W., "How PERT was Used in Managing the X-20 (Dayna-Soar) Programme", **IEEE Transactions on Engineering Management**, Vol. FM-II No.4, pp. 138–154.

Schoderbeck, P.O., "PERT/Cost: Its Values and Limitations", **Management Services**, January–February 1966, pp. 29–34.

Taylor, Bernard W. and Moore, Laurence J., "R&D Project Planning with Q-Gert Network Modeling and Simulation", **Management Science**, Vol. 26, No.1, pp.44–59, January 1980.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER IV

PART IV

COST PERFORMANCE

Cost Performance

Training Objectives

By the end of this chapter the participant will be able to:

1. Define cost performance.
2. Explain the position of cost performance vis-a-vis other performance measures.
3. Explain the meaning and use of budgets.
4. Define budget variances.
5. Analyse budget variances at different levels of specificity.
6. Apply other methods of cost control in project management.

COST PERFORMANCE

Contents

All this material can be covered in two sessions.
However, if detail is not required, one session is enough.

CHAPTER IV

PART IV

COST PERFORMANCE

Introduction

7.111 Technical and schedule performance determine the physical performance of a project. The one looks at how far the project has gone since inception and how much it still has to go. The other looks at how much time has already been spent on the project and some of the components thereof. The attempt is simply to establish how far the project is from the realization of its original objectives.

7.112 Both types of performance may have been achieved with little or no regard for the cost element. New personnel may have been hired in order to bring the project nearer to its completion. Materials may have been acquired at considerable cost or from relatively expensive sources. Equipment of a specialized nature may have been acquired to ensure that the project was completed on time.

7.113 The end result of all this is that the project ends up costing much more than originally intended. It should therefore be apparent that a system of cost evaluation should be incorporated in every project.

7.14 The determination of the cost of undertaking a project is an important exercise because, at the end of the day, everything must be reduced to a common denominator in order to allow for comparisons. Most often the denominator used is the monetary value or cost; it is a measure which is understood by most people. While cost analysis is a complex subject, in this manual, we shall outline only those aspects which are relevant for RDI management.

Cost in accounting takes on many forms but the most commonly understood form is the exchange price for a given resource. List other definitions of cost:

Project Budget

7.211 The beginning point in monitoring cost performance is the project budget. You will recall that a budget was defined as a financial plan for a project over a specified period of time. A budget, therefore, indicates how much money will be spent for each task or phase of the project and the total cost of the project. Without a budget it is not possible to monitor and control cost performance. We need to know the planned expenditure before we can decide whether there has been an over-expenditure or an underexpenditure.

7.212 In order to illustrate the use of cost analysis, let us take our tomato blight research project again. Assume that the following are the expenditures for each of the activities.

Table 7.1. Cost Comparison

Activity	Budgeted cost $	Actual cost $	Difference (variance) $
Literature Search	5,000	6,000	-1,000
Evaluation	1,000	800	+200
Research to find cause	20,000	16,000	+4,000
Research to find cure	30,000	40,000	–10,000
Test of cure for safety	10,000	30,000	–20,000
Manufacturing of batch for sample	8,000	5,000	+3,000
Total costs	$74,000	$97,800	–$23,800

7.213 The first level of analysis is to consider the total costs. In this example, we find that there is a cost over-run amounting to $23,800. We call the difference between the budgeted cost and the actual cost a **variance.** When the actual cost is greater than the amount budgeted, the variance is said to be **unfavourable.** On the other hand, when the budgeted cost is greater than the actual cost incurred, the variance is said to be **favourable.** So, in this case, we have an unfavourable variance of $23,800.

7.214 It may be necessary to break down this unfavourable variance into its sub-components. This enables us to find out the troublesome areas. This is shown in Table 7.1 in the last column which shows the difference between the first two columns.

7.215 With this kind of analysis, we are able to determine the activities which contributed to the cost over-run. It is clear that the two main contributors were :

• Research into the cure	$10,000
• Research into the safety	$20,000
	$30, 000

7.216 On the other hand, all the other activities had a favourable variance except for literature search which had a small cost over-run.

7.217 Having identified the two problem areas, it may be necessary to investigate further to find what specific area caused the problem. Let us assume that the breakdown of the expenditure was as follows in the case of Research into Safety.

	Planned expenditure	Actual expenditure	Variance
	$	$	$
Cost of materials used	5,000	25,000	20,000 U
Cost of personnel	3,000	4,000	1,000 U
Indirect costs	2,000	1,000	1,000 F
	10,000	30,000	20,000 U

U stands for unfavourable and
F stands for favourable.

7.218 With this further analysis, we are able to see clearly that the main cause of the problem was materials. These alone contributed $20,000 in the total variance which was subsequently offset by a saving in direct cost.

Material Variances

7.219a We can even go further and analyse why materials cost so much more than planned. To do this further analysis, let us assume the following additional data is available from the accounting office.

	Planned price per unit	Actual price per unit	Planned quantity	Actual quantity used
	$	$		
Chemical X	2	10	1,000	1,500
Chemical Y	3	20	1,000	500

7.219b We now wish to find out whether the cause of the problem was the price we paid for the materials or whether it was the quantity we used. Let us look at the price first because it is a common source of over-runs in the region.

	Actual Price Paid x Actual quantity		Planned Price x Actual quantity
X	10 x 1,500 = 15,000		2 x 1,500 = 3,000
		$12,000 (15,000–3,000) Price variance (Unfavourable)	
Y	20 x 500 = 10,000		3 x 500 = 1,500
		$8,500 (10,000 – 1,500) Price variance (Unfavourable)	

7.219c Having analysed the price position, we now turn to quantity because it is clear from the data available that there was a problem here as well.

	Planned Price x Actual quantity $		Planned Price x Planned quantity $
X	2 x 1,500 = 3,000		2 x 1,000 = 2,000
		$1,000 (3,000 – 2,000) Quantity usage variance (Unfavourable)	
Y	3 x 500 = 1,500		3 x 1,000 = 3,000
		$1,500 (1,500 – 3,000) Quantity usage variance (Favourable)	

7.220 We can now bring together all these computations so that we may get the overall picture.

Material	Price variance	Quantity variance	Total variance
	$	$	$
X	12,000 (U)	8,500 (U)	20,500 (U)
Y	1,000 (U)	1,500 (F)	500 (F)
	13,000 (U)	7,000 (U)	20,000 (U)

7.221 From this we can clearly see that for the two chemicals, all the unfavourable variances came from Chemical X. Indeed, were it not for the $500 favourable variance from Chemical Y, the unfavourable variance would have been $20,500.

7.222 Between price and quantity we can also tell that the greater cause of the variance was price variation (contributing $13,000) although the quantity usage also played a significant part. Again, it is Chemical X that was the main cause of the problem.

7.223 One could go on and on with variance analysis until the tiniest source of differences is identified. This is the job of cost accountants who are trained in this important aspect of cost control. How far we should go in analysing these differences will depend on what we intend to do with the information and, secondly, whether it is economical to do so. We wish to discourage variance analysis simply as an end in itself which is, sadly, what many accountants do not seem to appreciate. The depth of analysis should also never go beyond the understanding of the user of that information. So long as there is a satisfactory explanation of what went wrong, for instance, and this explanation is acceptable to RDI management, then that should be the end of the analysis.

Consider all the volumes and volumes of data kept in many accounting offices!

Labour Variance

7.224 In the above series of steps, we analysed the materials variance. We carry out a similar analysis for personnel costs and indirect costs. We deal with personnel costs first. In the initial analysis above, we indicated that the labour cost variance was $1,000 unfavourable. We wish to analyse this variance further. But before analysing this further, we must assure ourselves that the variance of $1,000 is really large enough to warrant further analysis. If the answer is yes, then we should proceed to do so. Specifically, we wish to know whether the cause is due to paying higher wages than planned or using more labour hours than planned. To do this analysis, we asked for and obtained the information below :

	Planned wage rate per hour	Actual wage rate per hour	Planned no. of hours	Actual no. of hours utilized
	$	$		
Research scientist	50	40	20	15
Technical backup	20	20	100	170

7.225 We deal with the question of wage rates differences first. In the case of research scientists, we note that the cost is $10 per hour. In the case of the technical staff there was no difference and thus our interest ceases there !

Is this really true?
Just because there is a zero difference does not mean that all is well!

7.226 On the quantity of time used by the two groups of people, our analysis shows that the main problem was in technical staff.

	Planned wage rate x Actual No. of hours $		Planned wage rate x Planned No. of hours $
Research scientists	750		1,000
		$250	
		Labour efficiency variance (unfavourable)	
Technical backup	3,400		2,000
		$1,400	
		Labour efficiency variance (unfavourable)	

7.227 We are now in a position to summarize the results as follows :

	Labour Efficiency variance
	$
Research scientists	250 F
Technical back-up	1,400 U
	1,150 U

Notice that in this case the major source of the labour costs variance was the inefficiency of the technicians.

Are things this simple in life?

7.228 One may now wish to find out why the technicians were inefficient. Perhaps they were not. The standards set might have been inappropriate. An analysis along these lines could be done just as we did one for materials. This will be left as an exercise for the reader.

Consider the case of your own RDI. Do you find this kind of analysis being done? If you do, do they go down to this level? If not, why do they not do it? What usefulness would such an exercise have for your RDI?

7.229 Perhaps we hired less qualified technicians. These would obviously take more time because of their inexperience. If this is the case, then the nil wage rate variance is misleading.

Perhaps we overpaid our technicians if we take into account their inefficiency.

7.230 Finally, perhaps the inefficiency is a result of hiring inefficient employees. But before we make this conclusion we must eliminate all the other competing hypotheses like the two mentioned above. We would like to note that in most RDIs most staff are paid on a monthly basis and this type of analysis may be unnecessary if not useless.

Do you think that there are additional possible explanations? Suggest some:

____

____

____

Overhead Variance

7.231 To conclude on cost variances, we turn to the analysis of indirect costs. These are also called research **overheads.** They are costs which are not identifiable with the end product, i.e. the research output. They include lubricants, electricity, water, indirect labour costs, director's salary, motor vehicles, etc.

7.232 It is usually useful to divide research overheads into two classes :

- **Variable overheads**
- **Fixed overheads**

Variable overheads vary in a direct way with some volume of activity. The most commonly used bases are direct labour hours and direct machine hours and apply more in production-oriented institutions.

Is this really the case when it comes to RDIs?

7.233 Fixed overheads on the other hand, do not vary. Once a research project has been started these costs have to be incurred. Since these costs are fixed, it does not make sense to attempt to analyse them on a per unit basis. They are a lumpsum that must be incurred once a project is accepted. They include such things as the specialized machinery that has to be purchased or invented. Note that fixed overheads have to be incurred whether a project is successful or not. However, where fixed overheads are phased over the life of the project and the project is terminated before some of the fixed overheads have been incurred, these become savings.

What percentage of R&D cost consist of fixed overheads in your RDI?

What potential problems can this lead to?

7.234 It is not useful to analyse variable overhead variances in the case of RDIs and we would suggest that scientists in such places should only be made aware of the need to be cost conscious when it comes to overheads because this is an area where large inefficiencies occur without most people being aware that they are there. Top management of RDIs have a major responsibility in this regard since failure to control such costs will lead to very substantial cost overruns.

Consider projects you may be familiar with and estimate as a percentage of total costs, the overhead costs. It should be quite high.

Disposal of Variances

7.311 Once variances have been identified and isolated usually by accounting personnel, they must lead to some action. By themselves they are of not managerial value. To be useful, their cause must be identified and corrective action must be taken in good time.

7.312 In the above examples, we took a relatively static position. The matter was treated as if variances are always identified at the end of the project. In real life, however, variances are identified continuously and corrective action is taken as soon as a variance has been diagnosed. We cannot overemphasize the need for early and timely reporting of such data as are needed for project control.

7.313 With the above caveat we now turn to the disposition of variances. The purpose of control is to ascertain whether the planned actions were, in fact, the ones taken, or whether the actual outcomes are the ones which differed from the plans, and finally, whether some corrective action is appropriate.

7.314 When a researcher receives a cost variance report, what should he do? Let us say that the variance is an unfavourable material price variance. There are a variety of events that could have caused that variance:

- **It could have resulted from an uncontrollable random event that will not affect future costs, e.g. a temporary price fluctuation.**

- **It could have been caused by an uncontrollable factor that is expected to continue in future, e.g. a permanent rise in raw material price.**

- **Finally, the variance may have resulted from some inefficiencies in the material purchasing operation that will continue until corrected, e.g. failure to purchase large quantities.**

7.315 Corresponding to these three causes there are three courses of action that the researcher can take if he knew the source of the variance:

- **If the cause of the variance is a random fluctuation, the best action would be to take no action, i.e. to leave things as they are.**

Is this a safe way to do things? Explain why or why not.

- **If the variance is the result of some permanent change in cost behaviour, the researcher cannot change costs but he can adapt to them. For example, he can look for substitute materials.**

- **Finally, if the variance is caused by some controllable factor the best course of action is to correct the inefficiency at the earliest possible moment.**

7.316 While we have enumerated the possible causes and appropriate actions, a researcher's problem is more complicated since the only information he has is the cost variance report. The variances could have been caused by a number of things.

7.317 In order to determine just what caused the variance the researcher should conduct an investigation. For instance, an investigation of a material usage variance may entail examination of the materials requisitions for the previous month to find a cause for the additional costs. Was it related to a particular experiment, technician, machine, etc.? Knowing the cause would enable an appropriate action to be taken and to avoid the problem in future.

In your RDI, who is in charge of checking the prices of the materials purchased? What, if any, responsibility does the scientist have? Can he purchase other equivalent chemicals if these are available?

7.318 When should a cost variance be investigated? Obviously not always because investigating a favourable variance may seem to be a waste of resources. But should all unfavourable variances be investigated? Or only those that exceed the budgeted amount by some predetermined percentage? These are questions which concern RDI management as well as financial personnel. Since they are important in the control process, we shall make a brief mention of some techniques used by accountants in determining when to carry out further investigations.

Techniques for Deciding When to Investigate

7.411 These techniques can be grouped into four categories :

(a) Materiality Level methods
(b) Statistical Control methods
(c) Non-normal Distribution methods
(d) Control Charts

7.412 In the case of <u>materiality level methods</u>, the analyst is concerned with deciding whether the difference or variance is <u>large enough</u> to warrant further enquiry. For instance, in the illustration above, a labour variance of $1,000 was considered <u>to be small in relation to the total variance to warrant further consideration</u>. This amount was only 5% of the total variance and thus did not appear to be "material" or significant. There are no hard and fast rules for determining materiality limits for all organizations. The level set may be determined by the institute director or by the accounting personnel. Through experience, they know when things may be getting out of control and the scientist may have to rely on their judgement.

Define "materiality" in connection with costs.

7.413 In some cases, however, the research scientist may have much more experience than the accounting personnel and, in this case, it is his responsibility to alert the project leader or RDI director if he is aware that there is need for control.

Since the scientist is the person who is most closely associated with the project, he will be the first one to notice if things are going wrong.

7.414 In some other cases, the process of control is managed by internal auditors. The internal auditor has a wide range of responsibilities over many aspects of RDI management and cost control is one of his major concerns. If it is felt that there is need for further investigation, he will most likely be the person to do the job. He should be seen as part of the RDI's management control system.

What is an auditor? An internal auditor? What does he do?

7.415 Statistical Control methods are more sophisticated than the simple materiality rules. The assumption in their case is that costs incurred in a given project follow some known statistical distribution. In these cases, variances to be investigated are only those which exceed — either side of the average — a specified level usually measured in terms of standard deviations.

For instance, the normal distribution. If you do not know what a deviation is, you should consult an elementary book on statistics.

7.416 These methods are particularly useful in production processes — e.g. in an oil refinery — and have little, if any, applicability in research institutes.

7.417 Non-normal distribution methods are even less useful than the normal distribution methods. They are mentioned here for the sake of completeness. Some are said to be distribution-free while others follow some known probability distribution. Unless one has very good reasons for deviating from simple parametric forms such as the normal distribution, there seems to be no real merit in considering these other forms.

7.418 Control Charts are used in certain production processes to determine acceptable fluctuation levels. They can be adapted to cost control if a high and a low level limit is set in advance. If the costs go beyond these levels, the control system is activated and someone is sent to investigate the cause and set in motion actions to bring the system back into control. The efficacy of such a system depends so much on timeliness of reporting and the immediate availability of a control device. As in the case of the two methods described above, it is quite unlikely that this method can be used in a research institution to any great extent.

Computers and Cost Control

7.511 In earlier days, a lot of cost recording and control work was done manually. Perhaps it is still being done manually in your RDI. It is not unusual to find these days that most of the routine cost control work is being carried out by computers. Many RDIs will not be able to afford a large computer but micro-chip technology has made it possible for even relatively small RDIs to acquire and operate their own microcomputers. Some of these microcomputers are not only quite powerful but they also do not cost a lot of money.

Do you have access to computers in your RDI? What type is it? When was it probably acquired? Is it or not? etc., etc.

7.512 A microcomputer is an exceedingly valuable aid in many management aspects and cost control, variance analysis and report generation areas where they can be used to great advantage. The only danger is that they can generate so much data that much more time than is necessary is spent trying to make sense out of such data.

7.513 We end this section of the manual by reminding the reader that any control system is only as good as the people who use the data and manage the organization. It is no use setting up a system for controlling technical, schedule or cost performance that is so complex that no one will understand it, leave alone use it. Whatever system we use must also be cost effective — that is, the benefits of using the system must always exceed the costs involved in setting up and maintaining the system. And these costs are not always financial!

Bibliography

Betty, Joseph, **Accounting for Research and Development**, London Business Books, 1976.

Brownell, P., "Participation in Budgetary Process — When it Works and When it Doesn't", **Journal of Accounting Literature**, Spring 1982.

Campbell, Richard A., "A System for Measuring Cost and Schedule Performance", **AACE Transactions**, Vol. 2, pp. 14–23, 1978.

Demski, J., "Optimizing the Search for Cost Deviation Sources", **Management Science**, April 1970.

Dittman, D.A. and Prakash P., "Cost Variance Investigation — Makovian Control of Markov Process", **Journal of Accounting Research**, Spring 1978.

Dyckman, T.R. "The Investigation of Cost Variance", **Journal of Accounting Research**, Autumn 1969.

Finison, J.H., "Control of Cost of Research and Development Projects", **IRE Transactions on Engineering Management**, Vol. PGEM-2, November 1954, pp. 1–15.

Kaplan, R., "The Significance and Investigation of Cost Variances: Survey and Extensions", **Journal of Accounting Research**, Autumn 1975.

Krogstad, J.L., Grudnitski G., and Bryant D.W., "PERT and PERT Cost for Audit Planning and Control", **The Internal Auditor**, August 1979.

Lindsay, Edwin, M., "Financial Management of R&D: A Case Study", **Management Review**, November 1971, pp. 29–32.

Van Steelandt, Frank V. and Ludo F. Gelders, "Financial Control in Project Management: A Case Study", **IEEE Transactions on Engineering Management**, Vol.1 EM-26, No.3, August 1979.

Project Termination

Training Objectives

By the end of this chapter, the participant will be able to:

1. Define project termination.
2. State why projects may be terminated.
3. Indicate procedures for project termination.
4. Describe the alternatives which should be considered before a project is terminated.

PROJECT TERMINATION

Contents

All this material can be covered in one morning session.

CHAPTER V

Project Termination

8.111 The hope and expectation of every research scientist is that the project being undertaken will come to a successful conclusion whereupon the problem, if such was the case, will have been solved to the satisfaction of all. If on the other hand, the project was of continuous nature, it will have been divided into phases and, in such a case, the hope is that the phase which was being worked upon will have been completed in readiness for the next phase.

What is the expectation in your RDI? Is it ever realized?

8.112 In many cases, projects do get completed successfully and all the personnel involved will be happy. The project may even generate other projects which pose a new challenge to the research staff.

8.113 In a significant number of cases, however, it may become necessary either to stop a project temporarily or even to abandon it altogether. The stoppage may be due to factors which are beyond the control of research staff or it may be due to a variety of internal problems which militate against continuation. Where a project is stopped in such a manner it is highly unlikely for it to be restarted or if it is restarted, it is done so under an entirely new structure, we may say that the project has been terminated. This chapter is concerned with those projects which are terminated before completion.

Before going on to the next page define "project termination".

Definition

8.211 Project termination may be defined as those policy actions which are taken to effectively discontinue further expenditure of resources on a particular project. These resources are financial, material and personnel resources. When a project is terminated, no additional finances will be expended on it, staff will be withdrawn from the project and deployed elsewhere and in some cases, the physical artifacts related to the project may be dismantled and distributed to other projects. In extreme cases, it may even be possible to sell off or dispose of in some suitable manner anything sellable or disposable for a given project.

How does this definition compare with yours?

How does this compare with a project you know which was terminated?

8.212 Project termination must not be confused with project completion, which is the realization of project objectives. Unfortunately, project termination implies, in many cases, failure of one type or another and it is our objective to find out why it was necessary to terminate the project. We should note, however, that termination of a project is NOT necessarily a bad thing. Indeed, there are many instances when it might be more sensible to abandon a project than to continue with it. It may also be that developments elsewhere have made our efforts no longer justifiable. Or it may be that continuing with the project may be more harmful than its discontinuation.

Reasons for Termination

8.311 We should spend some time on answering the fundamental question: Why terminate a project when we have spent so much time, money and effort on it?

8.312 The reasons can be divided into three categories:

(a) Reasons of a scientific nature

(b) Reasons of an economic nature

(c) Reasons of a moral or social nature.

Scientific Reasons

8.313 It could very well be that after monitoring and evaluating the progress of a given project, the technical staff are of the opinion that scientific bottlenecks exist and they are so serious that continuation of the current effort is not possible. For instance, it may turn out that before a scientific breakthrough is made, the current phase of a project cannot be completed. In such a case, there are two options: suspension until such a breakthrough is made or complete abandonment. This is why we believe that a thorough and honest technical performance evaluation is critically important.

Define a "scientific bottleneck." Give several examples.

____

____

____

____

____

____

8.314 In R&D work, this is a common occurrence. In the process of solving a specified problem, one has to solve many lesser problems. It might turn out that some of these lesser problems cannot be solved. Although the usual practice is to keep on trying, a time comes when the whole undertaking has to be terminated. This final decision is usually taken when the scientist gets convinced that the chances of success are virtually nil.

They could also be close to zero.

8.315 Scientific bottlenecks are of two types:

- **those that are solvable in the foreseeable future**
- **those that are not expected to be solved in the foreseeable future.**

The first type leads to the suspension of the project until the solutions to the bottlenecks are developed. The second type of the bottlenecks is the one that might justify project termination.

What are the dangers inherent in project termination?

8.316 A terminated project may, at a future time, be recommissioned. This occurs when advances in basic research (sometimes called pure research) make it feasible. That means that a project that is terminated now must be frequently reviewed to determine whether it can be usefully restarted.

If there are suspended projects in your RDI, explain how this type of review is achieved.

Staff Problems

8.317a Sometimes a project is closely associated with a certain individual or a small group of

We were told of a case where a whole project team died in a road accident scientists. Should this individual or key member leave the RDI, then the project cannot continue. This is particularly common when the individual researcher is an expatriate. In some cases, it may be that the scientist is local but has not been utilized to his capacity and he might be given an offer elsewhere which is, so to say, "too good to refuse".

In another case, the team literally disappeared when they took a short-cut through a neighbouring country. This underscores the danger of all project staff travelling together in one vehicle. How can such risks be reduced?

8.317b If the departure of an individual leads to the stoppage of a project, this is a good example of **inappropriate staff development strategies**. Every RDI should have a clear and effective staff development policy. This would ensure that no one single individual would be able to hold the institute at ransom intentionally or accidentally. This is not easy to implement in a developing country because qualified scientists are in short supply and the remuneration of the few who are available is usually not enough to encourage them to stay. This problem has led to what is called **brain drain**, i.e. the migration of qualified and highly needed scientists from their home countries to countries where the terms of employment are better.

8.317c Stopping the brain drain is a serious challenge to the leaders of the developing countries. It is a challenge because the incentives required to keep such staff are either duties, especially in the civil service, which are non-existent or are beyond the financial capability of the RDI. There are also certain rigid rules which make it impossible for RDI management, even if it so wishes, to compensate superior staff adequately.

What are some of the practical steps that can reduce this problem?

8.317d Some RDIs have attempted to minimize the danger of project abandonment due to the departure of an individual by requiring that every project be manned by two or more researchers. While this is a laudable policy, we should not forget that it involves underutilization of talent particularly where the additional personnel can be usefully deployed in other equally deserving projects. The only time when this policy is advisable is when one of the researchers is understudying an expatriate or a retiring scientist with a view to getting trained or taking over the project.

What is the policy in your own RDI?

Time Problems

8.318a A project may also be terminated for shortage of time. This frequently occurs when more urgent projects have to be done and resources (particularly personnel) have to be redeployed to these new projects. For example, one may be working on a project to produce, say, a cure for some disease. If suddenly a more dangerous disease is detected, he may be required to stop his old project and start working on the new one.

8.318b A second possibility is where a given project has been dragging on for a long time. This means that both human and other resources are tied in it. A time may come when a decision is made to abandon it so that these resources can be deployed elsewhere perhaps more productively.

If you have come across either of these two types, discuss examples with your colleagues.

8.318c The decision to terminate a project because it has taken a long time should be taken cautiously. Mere passage of time is not alone a sufficient reason. This is because research findings may sometimes take a long time to come by. In some cases, scientists work for years before they come out with any tangible results.

Do you agree?

8.318d Project termination for scientific reasons should be fully explained to all research staff especially scientists who may feel a strong sense of failure and may be led to believe that such failure was due to their inadequacies. A decision to terminate should only be taken when all avenues for further work have been exhausted.

How is termination of a project initiated in cases you know?

Reasons of an Economic Nature

8.319 A project may be terminated due to a variety of economic problems. In fact, many projects have been stopped because they have consumed resources which are far beyond the benefits expected to be derived from the eventual completion of the project. This is especially the case with social projects or various commercial or economic projects such as industrial plants or agro-industrial undertakings.

What are economic problems?

8.320 A very common cause of termination is that the project simply runs out of funds and all efforts to get additional funding are unsuccessful. In such a case, the RDI has little alternative except to abandon the project. We should note, however, that for a "good" project to fail to get funding to complete it is almost a contradiction in terms. Why is this so? A good project was defined in terms of its contribution to either mankind or a particular group of people. It therefore justified itself on the basis of the beneficiaries. Unless the structure of the benefits or the beneficiaries has changed dramatically, such a project should always be able to justify itself. If it cannot, then it would appear that it was not properly (fully) thought out and that is why it has, in fact, not been able to attract further resources.

Give examples you know.

Take some time to discuss this among your colleagues as it is not always easy to appreciate the truth of this.

8.321 Sometimes, however, the funds may not run out in the normal sense of the term. A project funded by a foreign donor might have been denominated in a given foreign currency, say U.S. dollars. Due to price changes and currency devaluations, it may turn out that the local cost can no longer be covered by the amount originally allocated. If the donor is unwilling to put any more money into the project, then there may be little choice except to terminate it if there is no one else willing to adopt it. This, again, is rare if it was a good project in the first place.

Perhaps the reverse could be true!

8.322 Funding may also cease due to changes in political alignments in the country. A change in political government may sometimes lead to a drastic change in ideological leanings. A project funded by a politically unacceptable donor will invariably be dropped.

This must be a rich area for cases. Discuss some you may be familiar with.

8.323 It is unfortunately the case that many projects in the developing world fail because of management problems. Under management, we include such issues as improper hiring of staff; unacceptable purchasing of materials, supplies and equipment; failure to follow laid down procedures in monitoring and evaluation; and sheer personal interest. In short, there are deliberate moves by some more people in the project to benefit themselves at the expense of the RDI and this leads to excessive costs which make it impossible for the

What is meant by
(a) Financial control?
(b) Internal control?

project to continue. This problem can be overcome if there is a good and effective system of financial (internal) control and if those who are responsible for misdeeds are speedily and expeditiously dealt with. While we do not wish to over-emphasize this point, we are sure that many readers will be familiar with instances of impropriety on the part of RDI staff.

Discuss some which you know.

8.324 A project may also be terminated because it fails to "deliver the results" as fast as was originally expected. The failure to deliver results quickly is not necessarily the fault of the researcher. He might be working on a project that is complex or which relies on results from other projects before it can be completed. As long as he can account for the way he has utilized the funds allocated to the project he should be allowed to continue with the project even though closer scrutiny may be expected of him.

8.325 However, we should note that the amount of funds available to fund projects are usually far less than what is required. Rationing is, therefore, inevitable. Every dollar allocated to a project is a dollar diverted from another (perhaps equally deserving) project. For this reason, additional funding will usually be hard to come by.

What is "rationing" of funds?

8.326 Funding problems are most severe in government funded projects. In addition to funds being limited, (few governments have enough money to finance their expenditure) getting approval is another major problem. Approving additional funds may require the endorsement of the legislature. This takes a long time.

8.327 To minimize funding problems, contingency provisions should always be in-built in the project budget. This does not mean that the budget should be fraudulently prepared but it does require that all the estimated expenditures be carefully analysed and costed.

List some ways in which a contingency allowance can be included in a budget:

____

____

____

____

8.328 A common financial problem in many developing countries is foreign exchange. Materials for research are invariably available in developed countries; so is equipment so necessary for the completion of projects. Since there is a shortage of foreign exchange and the little that is there is allocated to higher priority areas, it follows that research materials cannot be bought and if they are critical to the continuation of the project, then the RDI may have little option except to suspend or abandon the project altogether. In the course of visits to RDIs in the region while material for this manual was being collected, we found many instances of research staff who had practically foresaken their research work because chemicals and reagents could not be procured because there was no "forex" with which to buy them. In other cases, equipment could not be used because spares could not be purchased! Even worse, could not be serviced.

What is your own experience in this regard? Is it as serious as was found or more serious?

Reasons of a Moral Nature

8.411 There are occasions when the continuation of a given project may be questioned on moral or ethical grounds. Developments in the course of research may require that one gets into an area which touches upon personal social values and a scientist may feel that, he might be offended by continuing with such research work. A case in point is research on genetic engineering or "Cloning" as it is sometimes called. While no real ethical issues are involved when one is cloning mice and geckos, when the frontier is crossed and one starts to use human beings in the experimental research, the possibility is great that serious ethical questions will be raised.

If this is an issue in your RDI, it would be a good point to discuss it with others.

What are your views on this matter?

8.412 Another example is that of research work on AIDS, the immunodeficiency syndrome. It was reported in some research work that a newly developed medication was reducing the death rate of infected individuals at a rate that was significantly greater than that of those sufferers who were receiving a placebo or no treatment at all. When this result became available, the fundamental ethical question was whether it was right to continue administering the placebo to the control group. The reverse of this case (where those receiving the treatment were dying faster) has an even greater moral burden!

What is a placebo?

8.413a A project may also be terminated if it appears that its continuation may cause such devastation or misery that it is morally wrong for a responsible human being to continue with it. An interesting example, which also illustrates the scientists' dilemma is that of Albert Einstein and Enrico Fermi, the virtual inventors of the atomic bomb.

8.413b Einstein had theoretically derived an atomic bomb through his work on the relationship between matter and energy. Through his mathematical derivations, he was able to show that vast quantities of energy could be released from a small quantity of matter. Thus was laid the foundation. All that was required was the discovery of a type of matter that could be atomized and, even more fundamental, a method by which the required chain reaction could be initiated. Einstein and Fermi carried out a variety of research projects in the United States just before and during the early phases of the Second World War. The experiments were going on well and this is what literally frightened these two eminent scientists out of their wits. That is, they realized that what was until then a mathematical formula could be developed into a lethal weapon of destruction! They tried to marshall support for the project to be terminated and even appealed to the President of the United States to "stop it for God's sake!" But it was already too late. The rest is history.

Perhaps you have similar stories. Share them with your colleagues.

8.414 While research projects in RDIs in the region may not have such momentous consequences for mankind, the odd scientist will perhaps be confronted with moral or ethical questions which he cannot answer and, in such cases, it may be more prudent to terminate the project than to continue with it to its unpredictable conclusion.

8.415 The decision to terminate, as we have said, is NOT an easy one. At least not in those projects where a fair amount of psychological investment has been put in. Indeed, we would even go one step further and suggest that it is a lot easier to terminate a financially expensive project in which there was relatively little real commitment on the part of the scientists than one in which the financial commitment is low but the scientific and personal level of involvement was high. A moral

What do we mean by "psychological investment"?

____

____

____

lesson to be taken from this is that it is perhaps inappropriate for a scientist to be so deeply involved in a project that he ceases to be objective — objectivity is, after all, the true mark of a scientist. It should always be borne in mind that failure to reach an intended conclusion is a permanent concommitant of every research project. The researcher must be trained to develop a fairly thick skin when it comes to hard decisions, for these decisions are unavoidable in the realm of human enterprise. This is one more reason why we believe that there should never be individualized projects because it is always easier to share the burden of failure with someone else than to carry it on the shoulders of one scientist.

Perhaps you have experienced cases of this type. Describe a few.

Procedures for Project Termination

8.511 Given that a decision has been reached to terminate a project, the question which arises is whether there are formal procedures for the actual termination. To answer this question, we need to look at two related aspects of the project, namely:

(a) The procedural aspects of termination.

(b) The physical aspects of termination.

Procedural Aspects

8.512a By procedural aspects is meant the activation of the process of termination. The first issue is the decision itself. It is made in organization level — maybe the board or a cabinet decision. Someone has to convey the information to the project leader in writing if for no other reason than for record purposes. This could be by way of a detailed memorandum which will indicate at least the following :

(a) the authority within which the order for termination was taken.

(b) The effective date of termination.

(c) The reasons which led to the termination of the project.

(d) The fact that, where necessary, all other feasible alternatives had been exhaustively considered.

(e) The manner in which the project personnel, equipment and residual funds, if any, will be dealt with.

(f) The manner in which any liabilities, e.g. unpaid bills, debts and contingent liabilities, will be dealt with, including the office to which enquiries will be directed.

What is a contingent liability?

(g) If desired, it should be possible to at least express some form of gratitude to those people who were so heavily involved in the project and who now must be taken off.

(h) Finally, it should be indicated clearly who will be responsible for the physical termination of the project.

How is this done in your own RDI?

8.512b The type of procedure described above will be suitable where a formal shutdown decision has been taken. In some cases, this is neither possible nor is it necessary. A project may simply slowly grind down to a halt and, in the process, the wiser person will have read the "writing on the wall" and will have disappeared. Of course, this type of situation should never be allowed to occur in an RDI since it amounts to benign neglect (perhaps malicious neglect!). In a situation of this type, the project is literally abandoned like an exhausted mine shaft or a wrecked ship. It is not an exciting sight.

Perhaps you have seen some in your country.

Physical Termination

8.513a The process of physical termination will have been hinted at or ideally spelt out in the procedural termination memorandum. A responsible official will have been identified and been given the necessary mandate to wind up the project. Naturally, the detail into which he will get and the finances he will require will depend on the magnitude of the project.

8.513b For the small project, one or two people may be sufficient. Their tasks will generally be as follows :

(a) Take an inventory of all the equipment, materials and supplies in the project. These will include chemicals, reagents, any research specimens, research documents, data sheets, if any, etc. The inventory list will have to be countersigned by the project leader or the scientist in charge.

(b) Take an "inventory" of all the staff involved directly in the project. In this inventory will be their personal details, their qualifications, experience, years of service, etc. Such data can be verified from personnel records and is useful for future reference.

(c) From such records as may be available, determine what liabilities, if any, exist against the project. Establish the validity of each debt in a manner that is acceptable financially. For instance, an invoice from a supplier will only be acceptable if a delivery note, properly executed, is also available and, if possible, the subject matter is also seen.

(d) In a similar manner, determine whether there are persons who owe the project any money or to whom materials and equipment might have been lent. This may be much more difficult to establish unless very good records are maintained.

(e) Prepare a report for the RDI director indicating the contents of (a) to (d) above and suggesting how each of the terms involved might be dealt with.

This will almost certainly involve other research staff and even the director of the RDI himself. This report forms the basis upon which the final redeployment of staff and reallocation of other resources will be made. It is an important report.

(f) The director and his staff will make the decisions regarding disposition of all the items mentioned.

Compare this with your own experience, if any.

(g) Formal disposition documents will be prepared to accompany the redeployed staff, equipment and materials. For instance, a driver will be given a letter assigning him to another project and he will be required to report to the new office with that letter.

8.513c The detail will, as we have said, differ according to the magnitude of the project. The important point to bear in mind is that everything related to the project must be accounted for. Ideally, monetary values should be attached to all those items with a determinable value. This becomes important where some of the items in a project may have to be sold off. If proper values are not established, financial loss may occur and will be like adding insult to injury.

8.513d When a large project is being wound up, the basic procedures will be the same as in a small project. A lot of detail will, however, be expected and a team of people may be commissioned to do the actual winding up. A most important point to bear in mind in these types of situations is that every effort must be made to keep the cost of termination as low as possible. At the same time, it is suggested that the termination be carried out in an orderly and financially sound manner. Speed is not always the best solution. Orderly liquidation of equipment, if such is the case, might suggest a gradual process of sale instead of a mammoth auction.

Why is it important to keep the costs low?

____

____

____

8.514 Finally, there may be cases when physical reclamation or rehabilitation of a project site may be desirable. This is so where some ecological or environmental damage would result if the proper steps are not taken. Some R&D work may in fact be deleterious to the environment. Expensive though it might be, it is our view that this final clean-up is necessary and it is the mark of a responsible scientist.

Cite cases you may know.

Alternatives to Termination

8.611 Project termination could be a traumatic experience. It may also be unavoidable in economic and/or scientific terms. There may, however, be conditions where careful planning, monitoring and evaluation may have suggested some alternative course of action. It is to these alternatives that we now turn briefly before we end this chapter.

8.612 It should be apparent that project termination somehow affects the total performance of an RDI. The management of an RDI ought therefore to be concerned about how such performance can be measured.

8.613 One way of measuring the performance of an RDI is by calculating the ratio of projects abandoned to projects undertaken. If this ratio is high, then the RDI's performance is not of the required standard. What is "high" is a matter of judgement. Therefore, before a decision to terminate a project is taken, a thorough review should be undertaken to find out whether alternative ways of saving the project exist.

The danger here is that management may refuse to sanction termination so as to look good.

8.614 Alternatives will exist if the cause of the termination is of a financial or manpower nature. If funds prove to be insufficient and if the funding agency is reluctant to give additional funds, alternative sources should be identified and solicited. This solicitation may require some sacrifices and perhaps a loss of face but, as we said earlier, if the project is sound scientifically and/or economically, it is always possible to find someone somewhere willing to fund it.

8.615 Similar steps should be taken with regard to manpower. If a project leader leaves, attempts should be made to replace him. If one considers the worldwide market for scientific talent, he will be convinced that there may always be somebody willing to step into the shoes of a researcher who has left the RDI. Whether we can acquire them is another matter!

Is this practically true?

8.616 This means that the only time when a project has to be abandoned is when we hit a scientific snag. If we reach a stage where the existing body of scientific knowledge is found wanting, then we have to stop the original project and wait (or better still, attempt to extend the frontiers ourselves by further research if we can) from the knowledge to be extended. This is a

Is this a feasible alternative in developing countries? Explain.

common problem in much of the applied research work. Indeed, it is for this reason that some projects appear to be always around — sometimes dormant, sometimes very active. Scientific work may, in the final analysis, be one continuous exercise with finer and finer instruments having greater degrees of precision brought about by advances in the science of calibration.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

CHAPTER VI

Post Completion Project Evaluation

Post Completion Project Evaluation

Training Objectives

At the end of this chapter, the participant will be able to:

1. Define project evaluation and review.
2. State why there is need for project evaluation and review.
3. Identify the parties interested in project review and how their needs differ.
4. Apply various techniques of project review.

Post Completion Project Evaluation

Contents

All this material can be covered in two sessions. Due to its importance, we suggest careful reading.

CHAPTER VI

POST COMPLETION PROJECT EVALUATION

9.111 So far as projects are concerned, the projects have been identified, they have been budgeted for, they have been approved and implemented. Subsequent to this, they have gone through the process of monitoring and control with all the related aspects of technical, schedule and cost performance being considered. The project has finally come to an end. The question which presents itself now is: What next ? What do we do now that the process has come full circle?

9.112 An answer to this question has perhaps suggested itself if you have been following our discussion closely. At the end of the project we should start asking ourselves some of the questions which gave rise to the project in the first place. Some of these questions are:

- **Now that the project has been completed, has it answered the questions which had been responsible for its being there in the first instance?**

- **Has the problem which had to be solved been properly solved in actual fact?**

- **Have we in the process of solving the problem created new problems?**

- **Have new opportunities for further research been created?**

- **In retrospect, are there things that we did in the course of executing the project which we could have done differently or not at all?**

- **In what ways does the project fit in with the institutional mandate of the RDI?**

- **Has completion of the project contributed to national development and, if so, in what ways?**

Add your own questions of a similar nature.

9.113 All these questions and others of a similar nature comprise what is known as post-completion evaluation and review.

Definitions

9.211 <u>Evaluation</u> means a level-headed analysis of a situation with the objective of deciding, after the fact, whether the results are acceptable or satisfactory. It is a judgemental process in which a verdict is expected from the evaluator. The evaluator could be a person who was closely involved with the project or it could be an independent third party who is sufficiently knowledgeable about the subject matter of the project but who is removed from its performance and can therefore be objective in assessing the final product. Evaluation is a process of looking at the facts and judging the success or otherwise of a project on the basis of those facts.

Define "evaluation" in your own way:

9.212 <u>Review</u> on the other hand is a process of "backtracking" or going back to the beginning. A reviewer goes over the steps taken by the person in charge of executing the project and asking whether those steps were the best ones to have been taken. It is thus a process of identifying deviations, if any, from plan.

Define "review" in your own words:

9.213 Evaluation and Review are used interchangeably in many cases and in this chapter not much attention will be paid to their fine differences. But it should be remembered as you read this manual that there are some differences in meaning. Hindsight is the major advantage in a review; judgement, on the other hand, is the major characteristic in an evaluation.

Why Review?

9.311 It could be asked why a review is needed since the answers are already known. The project was either successful or it was a failure. So what is to be gained by doing all this extra work which might be unproductive? Shouldn't we rather be concerned with new projects which are going to contribute to national development instead of worrying about the past which we have absolutely no possibility of doing anything about?

What is your own view of this? Does the past really matter?

9.312 It might be tempting to agree with this line of reasoning because, in reality, it has some merit: we cannot change the past. We can only do something about the future. However, the future is a natural extension of the past. Experiences gained from past mistakes can be used to make better plans or to enable us to take more rational courses of action in the future. Time, to the wise, is the best tutor of all.

9.313 An evaluation or review is therefore necessary if we are going to be able to answer some of the questions — and others — posed at the beginning of this chapter. There are also many parties who are interested in the results of the RDI's projects and somehow these people have to be informed about the outcome of their separate "investments". Some of these investments may have been financial — as in the case of sponsors — while others could have been psychic — as in the case of all those research scientists who have spent so much time trying to solve the problem at hand or trying to produce a more workable system.

What is the meaning of "investment" for those people or organizations who are interested in RDI work?

9.314 The country is also interested in finding out whether, at the end of the day, the research efforts have been contributing to national development. If the answer to this question were in the negative, a case can be made for the reallocation of national resources to more productive uses. Recall that one of the major constraints facing any nation is a

Is this always the case when it comes to national research projects? Explain.

shortage of resources: financial, material and human. So whatever is put into a particular project must yield the greatest possible return.

Interested Parties

9.411 Let us now review the potential parties who have an interest in the results of the work being done in an RDI. We shall start with the scientist and move upwards to the highest authority involved in RDI work.

9.412 The **Research Scientist** is an interested party in the project. He is the one person who was there when everything was happening. He is the one who had to carry out the experiments, acquire the equipment, give instructions to the technicians, request resources (chemicals, reagents, supplies, etc.), report to his project leader, etc. The involvement by the researcher is personal and he is answerable, at the execution or implementation level, for its success or failure. In many cases, he is the one who initiated the project and, through his persuasion, perhaps managed to get the project approved and funded.

9.413 He is also likely to benefit substantially as a person if the project is successful. He might get a promotion at the very least; he might get a paper published or, if the project turns out to be a breakthrough, he might even get international recognition or a special award for the work done. The converse is true if the project is a failure: he will be blamed for lack of foresight, for messing things up, for not considering all the aspects of the problem, for looking at the wrong things, etc. The scientist, in short, will have been so personally involved with the project that he will want to know why success or failure was the final result and how the particular result came about.

What are some of the benefits of having completed a project successfully?

____
____
____
____

What happens in your RDI if the project is a failure?

____
____
____

9.414 The **Project Leader** will also have an interest in the project. If he is team leader, he was involved pretty much like the scientist and his concerns are pretty much the concerns of the scientist; his success, the success of the project and so on. He is the one who provides vision and direction to the project and, even more than the scientist, will be blamed if things go wrong. The

Who is more concerned in your RDI, about success or failure?

project leader may, in certain cases be so named because he possesses some special quality other than technical capability. This could, for instance, be exceptional managerial and organizational capability. In this case, his concerns might not be quite as personal as if he were a research scientist who was closely involved in the project.

This type of project leader is found in "social" projects. Do you know of cases where they have also been used in the more scientific types of research? You can spend some time discussing them.

9.415 Success or failure is also a concern to the project leader because of what it might imply in terms of his ability to get project leadership in the future. We know of cases where a project leader had to be dropped soon after the project was started because it became quite obvious that this particular leader lacked the ability to work with others. Mistakes of this nature can be costly and one does not wish to repeat them too frequently.

If you know of similar cases, share your experience with other participants.

9.416 The **Programme Head** is the person who is in charge of a particular programme involving a number of research projects having certain common properties. A programme head, unlike a project leader, has little to do with the day-to-day management of the project. His concerns are with the overall policy issues and coordination so as to ensure that the projects he has under his control are moving in the right direction. He is also concerned that a misdirected project is identified at an early point in time and corrective action taken. Where there is no programme structure, the head is probably the RDI's director. His concerns for success are not merely at the project level but success for the institution as a whole. One of these concerns is the consumption of "global resources" referred to in Chapter 3 but this time from a **post-hoc** basis — i.e. after the fact. If there were inter-programme re-allocations in the course of the implementation of the project, the programme head will want to know why it was done and, possibly, the effect of such re-allocations.

Chances are that he is the one who approved the re-allocations!

9.417 The **RDI Director** will be concerned about project results because he is the one directly answerable to the Council and to the country for this particular RDI. He is the one who has to account for all the work being carried out in the RDI and for all the resources consumed. His perspective is naturally quite different from that of

Shakespeare once said: "Lonely is the head that wears the crown". With your own RDI in mind, does the director appear lonely in this context? Explain to your colleagues.

the individual researcher or even the project leader. He will naturally be concerned about high level issues such as how the research work being done in his institute makes an impact on national development.

9.418 At the project level, he has to keep asking himself whether the project is proceeding in the **right direction** in terms of the results expected from the research work. He is the one who might have to give the authority to terminate a particular project if it appears that no useful results will be gained from the research. He is also the one who will have to decide whether a given project should be suspended and, for such suspended programmes, when (or if) they should be resuscitated. As some of these decisions are agonizing and painful, it is absolutely essential that the director be fully in control and be fully aware of his duties and responsibilities with regard to continuing projects (as well as with suspended ones).

A common way of avoiding or sharing this responsibility is to use the "committee structure." All major decisions are made by a committee and the director need not take all the responsibility. What method is used in your RDI?

____

____

____

____

____

The **Council (or Board)** of the RDI has overall authority regarding the institute's projects, programmes and policies. It is the Council which is answerable to the sponsoring agency — government, a donor or the international community at large — regarding the work being carried out in that institute. The vision of Council in this regard will determine whether or not the RDI's scientific and social legitimacy is assured. If it should appear that there is lack of direction or coherence in the work being carried out in the RDI, it is the Council which will be answerable. The effective participation of all members is important in ensuring that sight is not lost of the RDI's mandate.

9.419 Council need not be concerned with the specific details of project management. It cannot, on the other hand, deny responsibility for those projects since whatever is being done in the RDI is being done **for and on behalf of Council** although the individual member of Council may not feel that way. Unfortunately, when success has been achieved, it is very unlikely that Council will be recognized for the work leading to that success — this will invariably go to the actual research

What system is used in appointing Council members of your RDI? Does it appear to take into account their scientific interest?
Explain in as much detail as possible.

scientist who did the work or, in some cases, the institute. At first sight, it may appear, therefore, that there is no real motivation for anyone to want to become a member of a Council of a given RDI since, at the individual level, neither the pecuniary nor the scientific rewards are significant. But this is rarely true. Appointment to Council of an RDI could signify the recognition of the members as leaders in their own areas of expertise. This is sufficient reward for many council members.

9.420 The **Sponsoring Agency** also has an interest in projects. The sponsor could be a government ministry — as in the case of many national RDIs — or it could be a series of countries (e.g. the Foundations for various commodities like tea, coffee, tobacco, etc., which used to be in existence in the Eastern and Central African countries in the colonial days). Another sponsor could be an international agency such as the United Nations Economic Commission for Africa. Yet others may be a consortium of international donors in which case the RDI may solicit financial and material support from a large variety of sources.

9.421 Whatever the structure of the sponsoring agency, it is imperative that a formal procedure for reviewing the operations and projects of a given institute exist. This will ensure proper controls are in operation and the institute has a clear vision of what it is supposed to do in executing its mandate. It is also important to point out in this connection that changes will occur over time and these changes will imply a review of institutional mandate in light of changing social, scientific and economic circumstances.

If you belong to an "international" RDI, explain how frequently and for what purpose donor review is carried out. How does it differ from national reviews?

Summary of Parties and their Interests

9.511 In the chapter on Project Generation and Project Proposals, it was mentioned that morphological analysis is a useful way of generating research problems. In Table 9.1, we attempt a morphological scheme of the parties involved in RDI projects and their areas of interest.

Table 9.1

Interested party	Focus of interest	Frequency of interest	Measure of performance	Purpose of review	Disposition of results	Principal beneficiary
1. Research Scientist	Project operations	Continuous	Technical Completion	Education	Project leader	Self, Institute
2. Project Leader	Projects	Regular or Periodic	Technical & Schedule	Education/ Managerial experience	Institute Director	Institute
3. Programme Head	Fit with other projects	Periodic (short)	Successful total completion	Managerial experience	Institute Director	Institute Institute
4. Institute Director	Coordination	Periodic (short)	Successful total completion	Managerial	Council or Sponsor	Institute
5. Institute Council	Institutional mandate	Periodic (medium term)	Contribution to RDI	Evaluation of Institutional Mandate	Sponsor	Country
6. Sponsoring Agency	National or quasi-national objectives	Irregular (3–5 years)	Contribution to national development	Extent of contribution	Taxpayer	Country/ World

Review

9.512 In the previous section, we referred in general to the need for review whether it is at the individual scientist level or the institute level. The need for review varies according to the level of the unit being reviewed. Similarly, objectives of the review are naturally different as one moves up from the scientist all the way to the top. In similar manner, the techniques used may vary as one goes up the organizational ladder. Regardless of the level of evaluation or review, the overriding measure for the evaluation is the extent to which national expectations have been satisfied at each level of evaluation. While the parameters of evaluation will differ at each level, the common thread of the evaluation is the contribution of the project to national development.

Why should we evaluate at all?

9.513 As a caveat, we should mention that it is much more difficult at the lower levels to see how a particular research project might contribute to national development. This is especially the case with the more basic type of research where

Does this coincide with your own experience?

concern is with solving problems of a scientific nature and where no direct link exists with the nobler but more general goals of national development. A research scientist may not even be able to tell whether or how his project is going to enhance national development. One could even argue that if there is too much concern with contribution to national development, the scientist may lose interest in the project altogether. Probably, this is the case and in such circumstances, we would suggest that the director should be the person to be answerable with respect to the'potential or ultimate issues of national development and leave the scientists to do their work.

Is this necessarily true?

9.614 With this caveat in mind, we now look at some of the techniques which can be used in evaluating the success of completed research projects. Concern here is with completed projects since on-going projects are reviewed on an as-you-go basis in order to answer the questions we are trying to answer at this stage. Indeed, one of the major reasons for project termination (discussed in the previous chapter) could very well be that the project could no longer be justified in terms of potential contribution to economic development.

Refer to the same objectives of monitoring and control with respect to project termination.

Types of Techniques

9.611 Broadly speaking, there are four types of techniques which can be used in post completion project evaluation. These are:

- **Questionnaires**
- **Personal interviews**
- **Peer group evaluation in seminars**
- **Written reports**

9.612 The **questionnaire** is the simplest. It relies on a pre-specified set of questions which must be answered candidly. The respondent will normally be the research scientist himself while the administrator will be an independent person from a higher level in the hierarchy. It could even be the project leader himself. A questionnaire can be close-ended or it could even be open-ended. An open-ended questionnaire allows follow-up questions or explanations to questions depending on the answer given. A close-ended questionnaire on the other hand, requires the respondent to give answers which follow a specific format; there are no deviations or elaborations. For the evaluation of research results, we do not support the close-ended type of questionnaire.

A well known example is the "multiple choice" type of questionnaire.

9.613 In an **interview** the respondent answers questions directly from the interviewer who will have prepared a set of questions whose answers he is seeking. These questions can be precisely worded or they could be written down in point form. The experienced interviewer will be able to add new questions or delete existing ones depending on how the interview is proceeding. Care must be taken to ensure that the interviewer is as knowledgeable as the respondent on the subject matter at hand. Copious notes must be taken — which suggests that ideally there will be two interviewers, one of whom will be primarily responsible for recording the answers. In certain cases, a tape recorder could be used for later transcription but, most people tend to be less natural when they know that they are being taped. A tape recording should be avoided in this type of evaluation.

Why is this so?

9.614 **Evaluation by peers** has its strong points as was indicated in an earlier chapter. The mode in this case is a seminar type of presentation in which the research scientist gives his version of the story, then allows his peers to question him on any aspect they may wish to ask about. In a seminar presentation, rapporteurs are a critical aspect of the evaluation — they must record faithfully but succinctly whatever is being discussed. The record must be clear but not too detailed. The chairman of the session will be expected to provide adequate guidance to get a correct and proper summary at the end of the presentation. Proceedings of the seminar will ordinarily be distributed to members after confirmation by the principal participants that they constitute a correct record.

What are the duties of a session chairman?

9.615 **Written reports** constitute the final form of evaluation. Unlike the other three forms, this is a non-reactive form of evaluation. It is merely the researcher reporting on himself although, ideally, the report writer should be a person one step higher than the research scientist. A written report, to be an effective evaluation device, should be thoroughly discussed between the writer and the higher authority or his representative. Written reports are not a very good method of reviewing performance — they should only be used in conjunction with the other three techniques.

Of the four methods, which do you use in your RDI? Given a choice, would you use a different one? Explain.

9.616 In summary, the methods and their levels of usage are shown in Table 9.2.

Table 9.2 Techniques of Evaluation/Review

Technique		Primary Target
1.	Questionnaire	Research Scientist
2.	Personal Interviewer	Research Scientist
3.	Peer Evaluation	Research Scientist/Project Team
4.	Written Reports	Programme/Institute

Levels of Evaluation

9.711 Evaluation should be done at three different levels: at the research scientist level, at the project level and at the institute level.

Research Scientist Level

9.712 At the researcher's level, our concern will be with the following related matters which can be suitably arranged in a post completion evaluation questionnaire or interview.

- **In retrospect, was this scientist (or group of scientists) the one best suited to carry out the research?**
- **If the answer is yes, what were the reasons behind the original assignments?**
- **Could a different set of scientists (available to the RDI) have done the job better? In a shorter period of time? In a different way?**

They may not always be there!

- **Did the scientist keep proper and full documentation as the project progressed so as to enable someone else to pick up the project in case something happened to the researcher?**

This is a major deficiency in many RDIs and was a source of frustration to the Directors.

- **Did the scientist keep his immediate supervisor informed of key developments in the project?**

- **Did the scientist maintain an adequate level of consultation with the project leader or programme head?**

Another problem!

- **Did the scientist submit such reports as were required on time and in the formats required?**

We were informed that scientists are notoriously poor at this.

- **To what extent did the scientist work with his colleagues in the execution of the project? — i.e. was there an acceptable level of team effort where this was required?**

- **Was the scientist aware at all times of the project time schedules or did these appear to be of no concern to him?**

- **What was the indicated level of cost consciousness on the part of the scientist?**

- **Did the scientist appear to take an effective lead in the project's execution, especially with respect to either junior scientists and the technical staff?**

- **Did the scientists appear to have a clear vision of where this particular project fitted in the overall RDI's research effort?**

- **Did the scientist demonstrate any special creativity in solving the problems associated with the projects?**

You will want to avoid an "ivory tower" syndrome.

- **Did the scientist appear to be aware of potential projects which could have resulted from the current project?**

Finally, did the scientist have any awareness of this project's potential or actual contribution to national development?

At this juncture, you should add your own questions.

9.713 These questions can be broken down into three basic categories. The first category is concerned with the individual scientist and his **performance on the job**. We are trying to rate him in relation to the job which had to be done: was he good, average or poor? Could we assign him to a similar job given his performance on the **current** job?

9.714 The second category is concerned with the scientist's **potential for promotion or, at least, leadership**. Is he the kind of person who would rather be left to do his work alone and without much interaction with his colleagues or is he the person who is likely to play a pivotal role in the RDI's performance? If, for instance, a particular scientist can see right across all the relevant phases of a project, perhaps we have a potential project leader or programme head. We were told for instance, of a particularly productive research scientist in one of the Southern African countries who had "almost single-handedly produced seven different hybrids of maize". This scientist, however, abhorred anything to do with office work and the mandatory visits to the head office to discuss what he was doing or even his financial needs was a painful affair to him. He was happiest in the bush among his plants and his experiments.

How do project leaders get identified? What characteristics do you look for?

Is this the kind of scientist you want to have in a developing country? If not, how can this better quality be taken advantage of?

9.715 The third category of questions is concerned with the **overall research orientation in the context of national development**. This is what is known as the strategic level while the first two are operational and managerial levels, respectively. It might be argued that to expect a scientist to be aware of this level is expecting too much but then not every scientist is going to be the Director of the Institute!

How are Directors of RDIs identified? What was the background of your RDI's current Director?

9.716 It should also be apparent that each of the questions posed above may lead to other questions. In this manual, we have been concerned with generic issues and not specific formats. These latter can be incorporated in the design of a form

At this stage, we suggest that you attempt formalizing these questions into a review merely for an agricultural RDI.

for a given RDI. As a practical measure in fact, this first set of questions comprises the first part of the review questionnaire which is completed by persons in different organizational levels.

Project Level

9.717 Some of the questions raised in the first part have, in fact, touched upon certain aspects of the project itself. The concern was with the **interaction between the scientist and the project at the operational level.** We were concerned with questions of suitability and how the scientists actually **performed**. In this section, we wish to review the project as objectively as we can in order to determine if it was, in **retrospect**, a worthwhile project.

We emphasize once again, the value of hindsight.

9.718 Accordingly we shall seek answers to questions such as the following :

- **In retrospect, was this project a good, average or bad project?**
- **Which aspects of the project made it a good, average or bad project?**
- **In terms of planning, did we have a complete picture of the project? Where were the major drawbacks in the planning process?**
- **In terms of time, were we realistic in allocating the time for each phase of the project?**
- **In terms of personnel, were we realistic in assessing our human resources? If not, what were the problems encountered?**
- **How does the actual cost compare with the planned cost? What were the main causes of the cost overruns? Were these causes controllable or uncontrollable?**
- **Now that the project is completed, can its benefits (current and in the future) be justified in terms of the expenditures incurred?**

Few projects ever cost less than was originally planned!

List the various controllable and uncontrollable causes of cost overruns.

- **If we had to do the project all over again, would we do it the same way or some other way? Why, in each case is this?**

Be honest and fair about this!

- **Did the project, either during execution or upon completion, create new projects which the RDI can follow upon or was it a once-and-for-all project? What are these projects? — list them.**

- **Are there any significant publications or patents which can be produced as a result of the work just completed?**

Does your RDI have a policy concerning patents? Publications?

- **What are the potential or expected benefits to the country (or the world) as a result of completing this project? List them.**

- **Are there any negative effects which can (or will) result from the completion of this project? List them.**

9.719 As in the case of the individual scientist, there are other questions which are derivatives of the ones we have suggested above. They should be follow-up questions and answers, which when candidly and honestly given, can help in avoiding the pitfalls encountered in any project. Once again, we would like to reiterate that one of the primary reasons behind asking such questions is the education not only of the research but also of all the other people involved in the project. Research work is experimental — one is concerned about the learning process which can only come through time and experience.

Education here is viewed in terms of the learning process. Each new project is a lesson by itself. Do you agree with this observation?

Institutional Level

9.720 At the institutional level, concern now shifts from the operational and managerial aspects of a given project to a more generalized concern with the institutional mandate. We would like to ask whether this was the kind of project the RDI should have been involved in and how it relates to other projects (and programmes) being carried out at the institute.

9.721 Research projects in a given RDI, we suggest, should have **synergy effects**. What this means is that two projects, for instance, being done at the same institute should cost less, use less human and physical resources and/or get results faster than if they were being done in two separate institutes. If there is no synergy, perhaps they should neither belong to the same programme nor even the same RDI.

Some situations may be countersynergistic! List some examples of any that you know:

____

____

____

9.722 The questions to be asked here are more of a strategic nature. Some of them are:

- **In what ways did this project support or impede the progress of other projects in the institute?**

- **Are there any particular lessons which were learnt as a result of involvement in the project?**

- **Were there any strategic errors which were made in the course of acquiring and executing this project? If there were, were these internal to the RDI or were they external?**

- **In what ways did involvement in the project either enhance or impede the creation of a greater awareness of the work being done in this institute?**

You may add your own questions or modify the ones suggested here.

- **Did involvement in this project result in generating other projects or in attracting sponsors who might not have been otherwise attracted?**

- **To what extent and in what ways did this project's completion contribute to national development?**

At this stage we suggest that for a national training seminar, the trainer identifies a particular project with which he is familiar to develop a questionnaire. Does it address itself to all the pertinent issues?

9.723 As can be gleaned from this, there are not as many strategic questions which can be asked with regard to the congruence between the project and the mandate of the RDI. It is hoped, of course, that these questions were adequately covered at the pre-implementation stage. The purpose of asking them here is to get a new perspective with the advantage of hindsight.

Who Does the Review?

9.724 We now finally turn to the last issue: who does these reviews? Good management practice requires that the starting point of any review process is the unit or person to be reviewed. Since concern in the present is with projects, we would like to suggest that in the design of the review instrument, the first part should be completed by the scientist in charge of the project. Where several scientists are jointly working together, each of them can be asked to give his own independent evaluation of the project and to pass these upwards to the project leader or programme head.

An "instrument" in this context is a questionnaire, an interview document or a report.

9.725 The next part is completed by the project leader and the final part by the Director. Where a committee structure exists, the respective parts can be completed by this committee after the usual deliberations. Council if properly briefed, could review periodically each of the projects completed in the RDI and, at any rate, should have a report from the Director regarding ALL projects completed and in progress for an annual review by the Council.

A scientific committee should be relatively small — no more than five people.

Many RDIs routinely carry out this review. What happens in yours?

9.726 Regarding the review of the work of the RDI itself, this is a matter which is covered elsewhere in FAMESA's training manuals. We would point out that this is ideally done by an independent panel of scientists once every three to five years. Such a review is not only important in ensuring that the RDI has stayed within its statutory mandate but will, if properly done, suggest useful directions for the future and form the basis for the next strategic plan.

In one international RDI, this is done every three years by a panel of scientists from all over the world. This triennial review is taken very seriously by all the RDI staff.

Bibliography

Andrews, F.M. ed., **Scientific Productivity: The Effectiveness of Research Groups in Six Countries**, Washington UNESCO Press, 1979.

Bedrosian, Karakian, "Evaluating Your R&D Effort", **Innovation** No. 22, June 1971, pp. 46–55.

Crim, J. W., "Management Audit of a Research Institute: A Case History", **Journal of the Society of Research Administrators** Vol. 9 No.4 Spring 1978, pp. 14–20.

De Cotiis, T.A. and Dyer, Lee, "Defining and Measuring Project Performance", **Research Management**, Vol. 22, No. 1, January 1979, pp. 17–22.

Edwards, S.A. and McCarrey, M.W., "Measuring the Performance of Researchers", **Research Management**, Vol.16, No. 1, January 1973, pp. 34–41.

Galloway, E.C., "Evaluating R&D Performance—Keep it Simple", **Research Management**, Vol. 14, No. 2, March 1971, pp. 50–58.

Glass, E.M., "Evaluating R&D Organizations", **Research/Development**, Vol. 21 No. 1, January 1970, pp. 23–27.

Hackett, J.W., "Evaluation of Research", **Research Management**, Vol. 5 No. 3, May 1962, pp. 177–192.

Libik, G., "The Economic Assessment of R&D", **Management Science**, September 1969.

Wiener, R.S.P. and Bayley, J.C.R., "The Administration and Evaluation of Research Units and Projects", **British Journal of Sociology**, Vol. 22, No. 2, June 1971, pp. 193–199.

Winthrop, S.O., "Evaluating the Performance and Effectiveness of R&D Individual; Group: Total Organization", **Proceedings of the Sixth Annual Conference of the Canadian Research Management Association**, Edmonton, Alberta, October 1968, pp. 93–105.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

GLOSSARY

Glossary

ABC: *A*nalysis *B*ar Charting is a combination of the bar chart and networking approaches to planning. It can be very useful for calculating actual dates for commencement and completion of all tasks in a project, as well as isolating the critical path (see: CPM).

accounting: the administrative task of recording actual costs and expenditures so that comparisons may be made to budgets (planned costs and expenditures) for the sake of financial control.

applied research: the application of science and engineering to the development of new knowledge, new techniques, or new products of economic value to society.

appropriation: the decision to set aside money for R&D purposes; usually made by that government agency, or granting body, which controls financial resources for R&D.

bar chart: a planning tool which shows the start date, stop date and duration of R&D tasks which comprise a project — by means of a two dimensional array which depicts tasks on the vertical axis and time on the horizontal. Matrix data are comprised of lines or "bars".

basic research: fundamental application of scientific inquiry to understand the unknown and contribute to general knowledge.

bottlenecks: like the narrow neck of a bottle through which all contents must pass, a "bottleneck" in planning terms is that time in the course of an R&D project during which so many activities and task components converge on a single moment that resources, like labour, are severely taxed.

brain drain: a situation in which people who are gifted mentally emigrate to other countries usually in search of better economic prospects.

budgeting. the process of anticipating the costs, and planning the expenditure of financial resources for the execution of R&D tasks, projects and programmes.

capital budget: the plan for expenditure of money for the purchase of major equipment, facilities and real property.

cash budget: this is a detailed budget showing the amount of cash available at the beginning of, say, a month, the amounts of cash collected

	and paid out in the course of the month and, finally, the balance at the end of the month. It can be quite detailed.
contingency planning:	the process of developing secondary plans for R&D tasks, activities, administration, etc., which will be implemented if the primary plans turn out to be unrealistic.
control charts:	in systems theory, a chart used to monitor progress of a particular process. When an indicator reaches the lower or upper bounds prespecified for it, then action is taken to put the system back into line or control.
controllable costs:	are those costs which the manager in charge of a particular job for instance, can influence by either doing or not doing something about, e.g. maintenance of equipment. Uncontrollable costs are those costs which he cannot do anything about in the short run e.g. office rent.
controlling:	the process of making adjustments which correct for the deviation from planned progress.
control points:	those points-in-time, in the course of an R&D project, when some technical or administrative deliverable may be used as an indicator of the overall technical, cost and/or schedule performance of the project.
cost benefit analysis:	a systematic comparison of the cost of carrying out an R&D activity, and the value of that activity—quantified as much as possible.
cost overrun:	when the budgeted cost has been exceeded for a project, the situation is described as getting into a cost overrun.
cost centres:	a concept for financial management, which identifies the smallest particular organizational units or research activities to which costs may be held accountable in an RDI.
cost performance:	refers to the effectiveness with which costs in a project are managed.
cost prediction formula:	a quantitative technique for predicting the ultimate costs of an R&D project, or components of a project.
cost standards:	uniform and relatively stable guidelines for planning the costs of resources which are used frequently by the RDI.
CPM:	Critical Path Method refers to a quantitative technique which, when applied to network planning, is helpful in calculating the minimum time and sequence of tasks needed to complete an R&D project.

criterion: this is an objective goal which can be measured in relatively precise terms. It is the target towards which efforts are directed.

critical path: that path along a network plan which requires the greatest time for completion.

deliverables: general term to refer to the planned administrative or technical results of an R&D task, project or programme.

deliverables chart: an adaptation of the bar chart, the deliverables chart includes the identification of key results of technical work, or completion of administrative tasks associated with the project, like periodic activity and status reports to RDI management.

Delphi technique: a technique used in technological forecasting using selected experts in a particular field. Using an iterative approach a consensus is sought for the issue at hand.

development work: uses the results of applied research to create the form and substance of a new product, or process, or improve present ones.

deviation: the difference between anticipated (planned) and actual results.

directing: coordinating the application and expenditure of all resources required to complete an R&D task, project or programme — including labour, supplies, facilities and money.

direct costs: those R&D project costs which are directly traceable to the project — such as the cost of materials or labour.

discrete results: characteristic of an R&D project component which makes it easy to isolate technical outcomes.

dissemination: this is getting the results of research for instance, to the widest possible audience by extension work.

effectiveness: refers to the fit between actual results and some expected results. A measure of comparison must exist before effectiveness is assessed.

efficiency: this refers to the ratio between resources expended and the results obtained. For instance, costs incurred in two methods of completing an assignment may show that one of the methods is more efficient than the other.

favourable variances: are observed when the actual amount (e.g. cost of a product) is less than the amount budgeted to be spent. An unfavourable variance is the reverse.

feedback:	in control theory and in communications, the process of notifying the source that the system is being monitored or a message has been received correctly at its intended destination.
fiscal year:	that twelve-month period which the government has determined shall be the basis for budgeting all government activities. It may, or may not coincide with the January–December calendar year. It may, or may not coincide with the fiscal year of any other organization, e.g., an R&D client in the private sector.
forex:	this is used in developing countries i.e. a convertible currency.
fringe benefits:	personal compensation for work done, usually given in the form of insurance, paid leave, housing, transport or some other perquisite.
Gantt chart:	simply another name for a "bar chart"; sometimes called this because it was refined as an instrument for planning by a man named Gantt.
goals:	general statements of the desired outcomes of R&D.
indirect costs:	sometimes these are called overheads; they comprise all costs of R&D which are allocable to the general R&D function, but not to any particular project.
institutional mandate:	in the context of R&D, this is the primary charge which has been given to the institute. It identifies what the RDI was set up to do in broad terms.
management control:	refers to all those actions taken by management to ensure that organizational goals or objectives are achieved. It may be at the production level or at the organizational level.
materiality:	a term used in accounting to indicate that an amount is sufficiently large to warrant some form of attention.
milestone:	in project planning, points may be predefined to show when substantial results have been achieved. Such a point is referred to as a milestone.
monitoring:	the process of observing project progress and resource utilization, and anticipating deviations from planned expectations.
motivation:	these are efforts, positive or negative, to ensure that people in an organization behave in a manner that helps to attain organizational goals. Rewards and punishment are alternative motivational tools.

multidisciplinary approaches: in RDI research efforts are characterized by having scientists from a wide range of disciplines being involved in, say, a large project. Such a project may have biologists, chemists, veterinary experts, sociologists, etc. forming part of the project team.

networks: two-dimensional schema for depicting the principal technical elements of any R&D project, and their technical and scheduling relationships (see: ABC, CPM, and PERT).

objectives: very specific, highly technical, and frequently quantitative statements of the expected results of R&D project tasks.

operating budget: the plan for expenditure of money for all costs associated with actually running an R&D programme. It is based on the final appropriation of funds by the government.

operational control: is the process of assuring that specific tasks are carried out effectively and efficiently.

organization chart: a two-dimensional, rectalinear schematic of the roles, responsibilities and functional relationships among units in an RDI.

organizing: using the characteristics of structure to establish technical and authority relationships among units of an RDI.

overhead: the collection of indirect costs of R&D for an RDI.

parameter: a variable; usually a monitored budgetary threshold which triggers control decisions.

peer review: usually a technical review of R&D work, conducted by people who are of similar technical calibre and level of authority as the person responsible for the work.

PERT: Program Evaluation and Review Technique is the name given to a network approach to planning, monitoring, controlling and evaluation. Designed for particularly complex tasks, and detailed planning, it can be applied in a highly quantitative format. Otherwise it consists of a two-dimensional schematic of the relationships among tasks in an R&D project.

planning: setting appropriate objectives for R&D work; then selecting courses of action which are most likely to result in effective fulfillment of them. (see: strategic, and project planning.)

policy: principles of management establishment by the leadership of an RDI, to guide research managers at all levels of the organization.

portfolio: a general term which refers to the collection of R&D projects selected to fulfill RDI goals for national development.

programme: a group of R&D projects which are related either by a common technology, a common sponsoring organization, or a common executing unit of the RDI.

project: a discrete collection of R&D tasks which are required to fulfil a specific set of related R&D goals, and/or to resolve a specific development problem.

project evaluation: refers to a systematic comparison between the outcomes of the project and the planned results. The objective is to investigate whether the outcome is what was intended at the onset.

project generation: this is a conscious effort which has been systematically directed towards discovering new projects or researchable areas. This is an important activity in RDI management.

project planning: focuses on R&D projects; generates specific project objectives, tasks, resource requirements and schedules.

project termination: this may be achieved by the natural process of the project having come to an end or by the project being stopped before completion due to some event or executive action.

proposal: a statement of the objectives, methods, resources and management plan for an R&D project.

R&D: Research and Development is a phrase which encompasses the wide range of technical activities required to derive special knowledge and process which will help resolve the nation's development problems.

R&D management: the efficient and effective marshalling, allocation and control of human, material and financial resources in a manner which perpetuates a creative environment in which research and development activities may be used to focus technology on priority national development problems.

rate of completion: literally, how fast an R&D project is completed; quantitatively the slope or a line which represents the total proportion of technical work done (or planned to be done) for each control point (e.g., monthly, quarterly, annually, etc.).

rationing of funds: when funds are not sufficient to finance all projects, it is normal to cut down on the amount allocated to each project. This process is known as rationing.

RDI: Research and Development Institute is a general term we use in this manual to refer to any organization which is primarily responsible for the application of R&D methodologies for the solution of social and economic development problems.

Salmonella: a form of bacteria causing food poisoning. It has achieved some recent notoriety because of being associated with eggs which are not fully cooked before being eaten. It has nothing to do with fish (salmon).

schedule performance: refers to degree to which time spent on a project is within the time originally allocated to the project or a phase of the project.

strategic planning: focuses on RDI goals, scope of R&D activities, and RDI resources; establishes the relationship between RDI mission and national development goals; frequently serves as a basis for RDI policy development.

synergy: a term used to describe a situation in which the effect of two or more forces working together is greater than the arithmetic total of their individual effects. For instance, the combined effect of two drugs jointly administered may be greater than their effect separately administered.

task: one component of an R&D project, which may be differentiated from others by the distinct characteristics of its technical results, costs or scheduling.

task list: a fundamental basis for planning R&D projects — the task list is simply a list of those technical components of a project which may be isolated in discrete categories of technical activity, cost, or scheduling.

technical performance: refers to the extent to which technical aspects/or objectives of a project are achieved.

technically discrete: characteristics of an R&D project component which involves a distinct and separate methodology, which can easily be distinguished from the technical work on other components.

technology assessment: a technique for evaluating the consequences of applying technology to the problems of society.

unit costs: a standard for costs per piece, used for budgeting resources which have fairly stable costs, and which are used frequently by the RDI.

variance: the amount actual time, real costs or final R&D results deviate from the values anticipated in a plan.

work breakdown schedule: a list of R&D project tasks accompanied with task durations and dependent, or precursor tasks.

MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D PROJECT PLANNING, MONITORING AND EVALUATION

GENERAL BIBLIOGRAPHY

General Bibiliography

Ackoff, Russel, L., **A Concept of Corporate Planning,** New York: Wiley Inter-Science, 1970.

Amand, Davinder K., **Introduction to Control Systems,** Pergamon Press, New York, 1974.

Andrews, F.M., ed., **Scientific Productivity: The Effectiveness of Research Groups in Six Countries.** Washington, UNESCO Press, 1979.

Anthony, R.M., Dearden, J. and Vancil, R.F., **Management Control Systems,** Richard, D. Irwin, Inc., Homewood, Ill., 1965.

Archibald, R.D. and Cilloria, R.L., **Network-based Management Systems,** (PERTCPM), John Wiley & Sons, Inc., New York, 1967.

Argenti, John, **Corporate Planning: A Practical Guide,** London: Allan & Unwin, 1968.

Arnon, Itzhak, **The Planning and Programming of Agricultural Research,** Food and Agricultural Organization of the United Nations, 1975.

Arrow, K., "Control in Large Organizations", **Management Science,** April 1964.

Asian Productivity Organization, **Project Management in Asian Development,** Tokyo, 1979.

Batty, Joseph, **Accounting for Research and Development,** London Business Books, 1976.

Beck, G., **A Guide to Sources of Information in Planning,** London Centre for Environmental Studies, 1973.

Bedrosian, Karakian, "Evaluating Your R&D Effort", **Innovation** No. 22, June 1971, pp. 46–55.

Bhagavan, M.R., **Technological Transformation of Developing Countries,** Stockholm: Swedish Agency for Research in Co-operation with Developing Countries, 1984.

Binning, K. G. H., "The Uncertainties of Planning Major Research Development", **Long Range Planning,** Vol. 1, No. 4, June, 1969, pp. 48–53.

Brickner, W.H. and Cope, D.M., **The Planning Process,** Cambridge: Mass Winthrop, 1977.

Bromnnell, P., "Participation in Budgetary Process — When It Works and When It Doesn't", **Journal of Accounting Literature,** Spring 1982.

Buckley, J.W., **Research Methodology and Business Decisions,** National Association of Accountants, 1976.

Butler, Arthuer G. , "Project Management: A Study in Organizational Conflict", **Academy of Management Journal,** March 1973.

Cairns, R.W.," Planning for Research: The Problems Involved", **Research Management,** Vol. 4, No. 2, Summer 1961, pp. 107–118.

Cameron, Alastair, **Fundamental Research in an Industrial World,** London: Imperial College of Research and Technology, 1974.

Campbell, Richard A., "A System for Measuring Cost and Schedule Performance", **AACE Transactions,** Vol. 2, pp. 14–23, 1978.

Chang, Chi-wen, **Increasing Food Production Through Education Research and Extension,** Rome: Food and Agricultural Organization of the United Nations, 1963.

Childs, Marshall R., "Does PERT work for Small Projects", **Data Processing,** Vol. 4, No. 12, pp. 32–35, December 1962.

Chundleigh, P.D., "Research Allocation in Agricultural Research with Special Reference to Animal Production Research in the Higher Potential Areas of Kenya", Kitale: National Agricultural Station, 1974 (**Kenya Pasture Research Technical Report** No. 5).

Cleland, D.I. and King, W.R., **Systems Analysis and Project Management,** McGraw-Hill International Editions, London, 1987.

Collier, D.W., "Measuring the Performance of R&D Departments", **Research Management,** Vol. 20, No. 2, March, 1977, pp. 30–34.

Collier, James R., **Effective Long Range Business Planning,** Englewood Cliffs, N.J., Prentice-Hall, 1968.

Crim, J.W. "Management Audit of a Research Institute: A Case History", **Journal of the Society of Research Administrators** Vol. 9, No. 4, Spring 1978, pp. 14–20.

De Cotiis, T.A. and Dyer, Lee, "Defining and Measuring Project Performance", **Research Management,** Vol. 22, No.1, January 1979, pp. 17–22.

Demski, J., "Optimizing the Search for Cost Deviation Sources", **Management Science,** April 1970.

Dittman, D.A. and Prakash, P., "Cost Variance Investigation — Markovian Control of Markov Process". **Journal of Accounting Research,** Spring, 1978.

Drucker, P., "Controls, Control and Management", Chapter 31, In **An Introductory View of Management,** New York: Harper & Row, 1979.

Duncan, A., "The Economic Design of X Charts Used to Maintain Current Control of the Process", **Journal of American Statistical Association,** June 1956.

Dunne, E.J., Jr.,Ewart R. F., and Nanney D.M. , "What Happened to PERT? ",**Defense Systems Management Review,** Winter 1976.

Dyckman, T.R., "The Investigation of Cost Variance", **Journal of Accounting Research,** Autumn 1969.

Edwards, S.A. and McCarrey, M.W., "Measuring the Performance of Researchers", **Research Management,** Vol.16, No.1, January 1973, pp. 34–41.

Eicher, Carl, K. and Baker, D.C., **Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey,** East Lansing, Michigan: Michigan State University, 1982.

Eisner, H., "A Generalized Network Approach to the Planning and Scheduling of a Research Project", **Operations Research,** Vol.10, No. 1, January–February 1962, pp. 115–125.

Emery James C., **Organisational Planning and Control Systems: Theory and Technology,** London: Macmillan, 1969.

Feluman, David, **The Potential Role of Socio-economic Research in Agricultural Development,** (s.l.s.n.) 1978.

Finison, H.J., "Control of Cost of Research and Development Projects", **IRE Transactions on Engineering Management,** Vol. PGEM-2, November, 1954, pp. 1–15.

Flinn, J.C., and Denning, G.L., **Interdisciplinary Challenges and Opportunities in International Agricultural Research,** Manila: International Rice Research Institute, 1982.

Fuller, O. M., "Techniques for Planning and the Small Experimental Project", **Chemistry in Canada,** Vol. 28, No.10, November, 1976, pp. 30–33.

Galloway, E.C., "Evaluation of R&D Performance — Keep It Simple", **Research Management,** Vol.14, No.2, March 1971, pp. 50–58.

Gambino, A., *et al.*, "Costing and Reporting R&D Operations", **Research Management,** July 1979.

Gardem, N.K., "The Appraisal and Control of Complex Development Projects", **Research Policy,** Vol.1 No.2, April 1972, pp. 122–155.

Gargiulo, G.R., Hannoch, J., Hertz, D.B. and Zang, T., "Developing Systematic Procedures for Directing Research Programmes", **IRE Transactions on Engineering Management,** Vol.EM-8, No.1, March 1961, pp. 24–29.

Gauvin, W.H. "Planning an Industrial Research Programme", **Proceedings of the Fourth Annual Conference of the Canadian Research Management Association,** Vancouver, B.C., September 1966, pp. 129–132.

Gerloff, E.A., "Performance Control in Government R&D Projects: The Measurable Effects of Performing Required Management and Engineering Techniques", **IEEE Transactions on Engineering Management,** Vol.EM-20, No.1, February 1973, EM-8, No.1, March 1961, pp. 24–29.

Gibra, I. N., "Economically Optimal Determination of X Control Charts", **Management Science,** 1971.

Glass, E.M., "Evaluating R&D Organizations", **Research/Development,** Vol.21, No.1, January 1970, pp. 23–27.

Gluck, F.W. and Foster, R. N., "Managing Technological Change: A Box of Cigars for Brad", **Harvard Business Review,** Vol.53, No.5, September–October, 1975, pp. 139–150.

Gmitter, G.T., "Towards a Better Understanding of Industrial R&D and Cost Control", **Research Management,** Vol. 8, No.4, July 1965, pp. 229–239.

Gray, J.A. and Wolff, S.P., "The Changing Face of Research and Development in the Public Sector", **R&D Management,** Vol. 6, No.3, June 1976, pp. 105–108.

Gunz, Hugh P. and Pearson, Alan, "How to Manage Control Conflicts in Project Based Organizations", **Research Management,** Vol. 22, No.2, pp. 23–29, March 1979.

Hackett, J.W., "Evaluation of Research", **Research Management,** Vol. 5, No. 3, May 1962, pp. 177–192.

Hanseeb, Mansour Ali, **Monograph on Biomedical Research in Sudan,** Khartoum: Khartoum U.P., 1973.

Hardingham, R.P., "A Simple Model Approach to Multi-Project Monitoring", **R&D Management,** Vol. 1, No.1, October 1970, pp. 43–47.

Hill, L.S., **Towards An Improved Basis of Estimating and Controlling R&D Tasks,** The Rand Corporation, Santa Monica, California, May 1966.

IRI Staff Report Control of Research and Development, **Research Management,** Vol. 6, No. 6, November 1963, pp. 435–449.

Jodka, John, "PERT (Programme Evaluation and Review Techniques) A Control Concept Using Computers", **Computers and Automation,** Vol. No.3, pp. 16–18, March 1962.

Johnston, *et al.*, **Directing Technology: Policies for Promotion and Control,** New York: St. Martins Press, 1979.

Jones, Harry, **Preparing Company Plans: A Workbook for Effective Corporate Planning**, Guildford: Gower Press, 1974.

Kahalas, H., "A Look at Major Planning Methods: Development, Implementation, Strengths and Limitations", **Long Range Planning**, August 1978.

Kaplan, N., "The Role of the Research Administrator", **Administrative Science Quarterly**, Vol. 4, June 1959, pp. 20–42.

Kaplan, N., "The Significance and Investigation of Cost Variances: Survey and Extensions", **Journal of Accounting Research**, Autumn 1975.

Keaton, P.W., "Five Ways to Review R&D Programmes", **Research Management**, Vol. 23, No.5, September 1980, pp. 8–9.

King, L.T., **Problem Solving in a Project Environment**, John Wiley & Sons, Inc., New York 1981.

King, W.R., "Project Planning Using Network Simulation", **Pittsburgh Business Review**, Vol. 38. pp. 1–8, 1968.

Koontz, H. and O'Donnel, C., **Management: A Book of Readings**, McGraw-Hill Book Company, 1964.

Koontz, H. and O'Donnel, C., **Management : A Systems and Contingency Analysis of Management Functions**, McGraw-Hill Series in Management, McGraw-Hill Book Company, 1976.

Kreitner, R., **Management**, Houghton Miflin & Company, Boston, 1983.

Krogstad, J.L., Grudnitski, G. and Bryant, D.W. , "PERT and PERT Cost for Audit Planning and Control", **The Internal Auditor**, August 1979.

Lee, Robert, **Optimal Estimation, Identification and Control**, MIT Press, Cambridge, 1964.

Liberatore, Matthew J., "An Incremental Approach for R&D Project Planning and Budgeting", **Research Management**, Vol. 24, No.2, pp. 17–20, March 1981.

Libik, G. "The Economic Assessment of R&D", **Management Science**, September 1969.

Lindsay, Edwin, M., "Financial Management of R&D: A Case Study", **Management Review**, November 1971, pp. 29–32.

Magee, R.," Cost Control With Imperfect Parameter Knowledge", **Accounting Review**, January 1977.

"Making Project Management Easy", **Datamation**, April 1978.

Mansfield, Edwin, **Industrial Research and Technological Innovation: An Econometric Analysis**, London: Longmans Green, 1968.

Martin, Jon W., "Managing Small R&D Projects — A Learning Model Approach", **Research Management**, Vol. EM-I, No. 1, March 1964, pp. 29–42.

Mbilinyi, S., **Agricultural Research Problems in East Africa**, Dar-es-Salaam: Economic Research Bureau, University of Dar es Salaam, 1972.

McCoughlin, Peter F., **Research on Agricultural Development in East Africa**, New York: Agricultural Development Council, 1967.

Mlize, J.H., White, C.R. and Brooks, G.H., **Operations Planning and Control**, Englewood Cliffs, N.J., Prentice-Hall, 1971.

Mogila, Robert F. and Tweedy, Robert H. "Making the Most of Limited Agricultural Research Money", **Agricultural Engineering magazine**, July/August 1986, pp. 24.

Mohamedali, O., **Agricultural Research and Agricultural Information Services for East Africa**, 1978.

Molieri, J.T., "Management Control and Monitoring Techniques", **IEEE Transactions on Engineering Management**, Vol. EM-10, No.2, June, 1963 pp. 57–64.

Molnos, Angela, **Addresses Relevant to Research and Development in Kenya, Tanzania and Uganda**, 1967.

Murelins, Olof, **An Institutional Approach to Project Analysis in Developing Countries**, Paris: Development Centre of the Organization for Economic Co-operation and Development, 1981.

Murphy, S.R., "Five Ways to Improve R&D Efficiency", **Research Management**, Vol. 24, No.1, January 1981, pp. 8–9.

Moseman, Albert H., **Building Agricultural Research Systems in Developing Nations**, New York: Agricultural Development Council, 1970.

Moskowitz, H. and Bullers, W.I.," Modified PERT versus Practice Assessments of Subjective Probability Distributions", **Organisational Behaviour and Human Performance**, Vol. 24, 1979.

Muturi, S.N., **Resource Allocation in Agricultural Research in Kenya: Part I: Findings and Recommendations**, Nairobi: National Council for Science and Technology, 1982.

National Council for Science and Technology, Kenya. **A Manpower Training Plan for Agricultural Research Systems in Kenya, 1983–1987**, The Hague: International Service for National Agricultural Research (An ISNAR/NCST report).

Nicomani, W.K., "Planning Techniques in Zambia", In **Economic Bulletin for Africa,** Vol. XII No. 1, 1976, pp. 69–92.

Paige, H.W., "How PERT Cost Helps the General Manager", **Harvard Business Review,** pp. 87–95, November–December 1963.

Papadakis, Inan, **Agricultural Research Principles, Methodology and Suggestions,** Buenos Aires: Librode Edicion Argentina, 1970.

Parker, R.C. and Sabberwal, A.J.P., "Controlling R&D Projects by Networks", **R&D Management,** Vol. 1, No. 3, June 1971, pp. 147–153.

Pessemier, E. A., "Financial Planning and Control of Industrial Research and Development". **Long Range Planning,** Vol . 3, No. 2, December 1970, pp. 32–39.

Pidgeon, G.W.F., **Financial Control in Developing Countries: With Particular Reference to State Corporations,** London: Longham, 1971.

Pinstrup, Anderson P ., **Agricultural Research and Technology in Economic Development: Impact of Agricultural Research and Modern Technology on Food Production, Economic Growth and Income Distribution in Developing Countries,** London: Longman, 1982.

Poccock, J.W., "PERT as an Analytical Aid for Programming Planning: Its Payoff and Problems", **Operations Research,** Vol. 10, No. 6. pp. 893–903, November–December 1962.

Reader, R.D., "Aspects of Project Control in R&D", **R&D Management** Vol. 7, No. 2, February 1977, pp. 77–84.

Ritchie, E., "Planning and Control of R&D Activities", **Operations Research Quarterly,** Vol. 23, pp. 477–490, December 1972.

Robertson, D.C., **Project Planning and Control: Simplified Critical Path Analysis,** London: Heywood Books, 1967.

Ryan, W.G., "Management Practice and Research — Poles Apart", **Business Horizons,** June 1977.

Sadow, R.W., "How PERT Was Used in Managing the X-20 (Dyna-Soar) Program", **IEEE Transactions on Engineering Management,** Vol. FM-ll, No. 4, pp. 138–154, December 1964 .

Schoderbeck, P.O., "PERT/Cost: Its Values and Limitations", **Management Services,** January–February 1966, pp. 29–34.

Souder, W.E., "An R&D Planning and Control Servosystem: A Case Study", **R&D Management,** Vol. 3, No.1, October 1972. pp. 13–21.

Taylor, Bernard W. and Moore, Laurence J., "R&D Project Planning with Q-Gert Network Modelling and Simulation", **Management Science,** Vol. 26, Vol . 1, pp. 44–59, January, 1980 .

Taylor, H . M ., The Economic Design of Cumulative Sum Control Charts for Variables", **Technometrics,** August 1968.

Tourangeau, Kevin W., **Strategy Plans for Your Business,** New York: McGraw-Hill Book Company, 1981.

The Workshop on Agricultural Research Administration, Nairobi, Kenya, 27–30 June 1977, Association for the Advancement of Agricultural Sciences in Africa (AAASA), Addis Ababa AAASA, 1979.

Van Steelandt, Frank V. and Gelders Ludo F., "Financial Control in Project Management: A Case Study", **IEEE Transactions on Engineering Management,** Vol. 1 EM-26, No.3, August 1979.

Wiener, R.S.P. and Bayley, J.C.R., "The Administration and Evaluation of Research Units and Projects", **British Journal of Sociology,** Vol. 22, No. 2, June 1971, pp. 193–199 .

Winthrop, S.O., "Evaluating the Performance and Effectiveness of R&D Individual; Group: Total Organization", **Proceedings of the Sixth Annual Conference of the Canadian Research Management Association,** Edmonton, Alberta, October 1968, pp.103–105.

World Bank, **Agricultural Research Sector Policy Paper,** Washington D.C.: World Bank, 1981.

Cover and Layout Design
Winnie Oyuko
Typesetting
Doreen Munene, Gladwell Gichuru, Jemima Wambui
Proofreading
Harrison M. Adunga, Mary Kegode, Dolorosa Osogo
Illustrations
Newton Muunga Komeri

ICIPE
Science
Press

ISBN 92 9064 072 3