Management Manual for

Productive R&D Institute Facilities and Materials Management

ADMINISTRATIVE MANAGEMENT OF RESEARCH PROJECTS IN EASTERN AND SOUTHERN AFRICA (FAMESA) Development (R&D) management training network of national R&D institutes, management and 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

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Productive R&D Institute Facilities and Materials Management

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The theme of materials management covers a complex area and, indeed, it forms a very specialized body of knowledge for which studies are undertaken leading to professional qualifications, such as membership of the Institute of Purchasing and Supply (IPS) or of the Institute for Materials Handling (IMH). However, this Manual is not intended to meet the requirements for such professional studies. Rather, it aims at equipping practising managerial staff in developing policies and procedures for managing facilities, materials and supplies.

Financial and Administrative Management of Research Projects in Eastern and Southern Africa (FAMESA), in its intensive profile survey of research and development (R&D) institutions (RDIs), has carefully identified areas of major constraints within the facilities, materials and supplies sections of RDIs that require strengthening. The present Manual focuses on these issues.

Materials management usually incorporates such elements as bills of materials, parts and materials standardization, inventory system and data banks, procurement procedures, and transportation. Indeed, materials management as a total concept encompasses all elements of the business system. However, in the case of the RDIs, the recognized needs concentrate on the way the facilities and materials are managed: supplies and materials consume as much as 30–40% of the budget of RDIs. Furthermore, as RDIs expand their operations, the size, complexity and diversity of materials and supplies deployed increase, thus necessitating the need for proper asset management.

The approach adopted in this Manual provides the general basic concepts of R&D management, in order to enable the responsible officers to visualize the context in which they are expected to provide service to their institutions. In addition to the theoretical approach, the Manual contains pertinent case studies and exercises, which are purposefully provided in order to deepen the reader's grasp of the concepts.

Participants at a recent workshop for the validation of the Manual stressed the need for well-formulated procedures; and FAMESA is glad to incorporate these into the Manual. These procedures may be adopted by any RDI; but it should be stressed that they may need to be modified under certain circumstances.

The development of this Manual has been funded by the International Development Research Centre (IDRC), of Canada. FAMESA wishes to register its appreciation for the donation, not only for this Manual but also for other support for FAMESA which IDRC has continued to render through its Regional Office in Nairobi.
Secondly, FAMESA wishes to thank all the R&D institutions who kept their doors wide open to FAMESA, especially by allowing its consultants carry out their needs survey. Participants to the curriculum validation workshop from these same institutions have played a commendable role in ensuring that the Manual would be suitable and relevant for use within the RDIs.

Consultants were deployed at all levels of the planning and preparation of the Manual. FAMESA wishes to record its special thanks to Professor Jean Nollet of Ecole des Hautes Etudes Commerciales, University of Montreal, Canada who wrote the final text for this Manual; and the needs survey consultants — Dr. Joseph Kimura, University of Nairobi, Kenya; Dr. Venant Mvano, of the Eastern and Southern African Management Institute (ESAMI), Arusha, Tanzania; Mr. Isidor J. Temba, of the Institute for Development Management (IDM), Mzumbe - Morogoro, Tanzania; and Mr. Agonafer Makonnen, of the Ethiopian Management Institute (EMI), Addis Ababa, Ethiopia.

Finally, FAMESA is grateful to its Coordinator, Dr. Luka O. Abe, who has guided and coordinated all FAMESA activities since its inception, leading to its current level of performance.

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26th August 1986
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MANAGEMENT MANUAL FOR PRODUCTIVE R&D:
R&D INSTITUTE  FACILITIES AND MATERIALS MANAGEMENT

INTRODUCTION
INTRODUCTION

Training Objectives

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

1. Explain the need for R&D management training.
2. Understand some basic aspects of the management of facilities and materials.
3. Outline the purpose and contents of the Manual.
4. Describe the Manual format, and the variety of ways in which it may be used for training purposes.
5. Adapt the Manual for their optimum mode of study and learning.
INTRODUCTION

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All of this material can be covered in one session, if it has been studied on an individual basis prior to the session.
INTRODUCTION

1. Need for Management Training

Introduction

This manual is part of the second series on Productive R&D Management, based on solid research experience by FAMESA on the management of RDIs in Eastern and Southern Africa and other developing countries. It has been the experience of FAMESA managers that productive management of R&D institutes must be linked to the development goals of the country, in order to be really useful. These series represent a unique training experience. Hopefully, they will stimulate sufficient reaction to encourage international sponsors to join in this R&D management training venture.

Observations on R&D Facilities and Materials Management

Land, buildings and equipment constitute facilities. These are necessary to make possible the research going on in RDIs. Adequate management of facilities therefore contribute to efficient operations. As for materials, they are often directly used in the research process and do not have a useful life as long as facilities do. Materials include chemicals, biological specimens, etc. To manage materials properly constitutes a challenge which can be met satisfactorily by using a philosophy and methods similar to those in this Manual. Some management problems are not easily controllable by the institutes, because they are the result of the environment in which they are operating. This should be seen as making the challenge even more interesting...

This Manual on R&D Institute Facilities and Materials Management is based on observations in 12 RDIs and discussions with many of their managers. Fieldwork revealed that a considerable number of problems existed regarding the topics covered in this Manual. It is the purpose of FAMESA to advise, through this Manual, on the possible measures to apply so as to solve these problems.

Consultancies and training exercises led to four fundamental observations which had the greatest influence on this Manual approach to the subject of R&D Facilities and Materials Management.
1. There are important differences among RDIs, in terms of users' knowledge and application of facilities and materials management concepts. Therefore, there is an effort to cover topics in a way that is orientated mostly for those with little formal training in the area, although many concepts are developed at a level that all readers will find useful and challenging.

2. The four areas which are of greatest concern to a majority of RDI managers are determination of order quantities and reorder points, maintenance, procurement procedures, and stores. Therefore more emphasis is put on these topics than on most of the others.

3. When a topic is related to more than one of the areas of equipment, materials, land, and buildings, it is covered in each of the appropriate areas, although with a different scope if justified. The alternative was to discuss a topic only once, and to refer the reader to the appropriate section.

4. The greatest need for management training among RDI managers is a basic understanding and overview of management as a process which can enhance R&D productivity throughout the R&D institute. Although a number of concepts are presented, the emphasis is clearly set on the importance of a proper philosophy in the management of facilities and materials. In fact, an effort has been made to emphasize the managerial — and therefore practical — implications of the options available to RDI managers in the management of facilities and materials.

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.

Objectives of Facilities and Materials Management

Fundamentally, the objectives of Facilities and Materials Management are the following:

1. To acquire the right quality of materials, at the right time, in the right quantity, from the right source and at the right price.

2. To supply the RDI with a steady flow of materials and services to meet its needs.

3. To ensure continuity of supply by maintaining effective relationships with existing sources and by developing other sources of supply.

4. To buy facilities and materials wisely.

5. To protect and maintain facilities so as they remain in good condition.

6. To manage inventory so as to give the best possible service to users at the lowest cost.
7. To maintain sound cooperative relationships with other departments, thus providing information and advice as necessary to ensure the effective operation of the institute as a whole.

8. To develop staff, policies, procedures and an organizational structure to ensure the achievement of the above objectives.

This Manual addresses each one of the issues related to these objectives, and many others which are useful in the management of RDIs.

While the Manual in Series I details management techniques in planning and budgeting, it does so in a more general context of management as a collection of tools for improving R&D productivity. This Series II Manual uses a similar approach and philosophy as the first one. It starts with an overview of R&D management and relates its particular skill emphases to the whole management process.

Opportunities in Management Training

R&D Facilities and Materials Management is a part of Management Training. Considering that all managers aim at reaching organizational objectives by a proper utilization of human, financial and material resources, there is an obvious need for training when one considers all the complex activities which constitute the area of management. It is clear that concepts in this area are generalizable, although it is necessary to adapt these to specific situations. These series of Manuals on productive R&D focus on the customization of management training for research and development institutes (RDIs) in Eastern and Southern Africa.

It is not difficult to manage. What is more difficult is to manage properly. There is a continuous need to upgrade knowledge, in order to make possible a significant improvement in the utilization of resources. It should be emphasized that proper management of the research aspects of an RDI does not imply that there is simultaneously a proper management of the administrative aspects. However, it is necessary to manage well the administrative aspects to run efficient research operations. Therefore, these series of Manuals could contribute substantially to the management not only of the administrative aspects, but also to those related to research.

These series of FAMESA Manuals contribute to improved management which constitutes an interesting way to use funds better and result in economies which can benefit to any department in the RDI. This corresponds to receiving additional funds from inside rather than from outside sources. Overall, it can be said that better management of RDIs should constitute a major objective for all nations, because it represents an important way to improve the use of scarce resources and the likelihood that the national objectives embedded in RDIs will be attained.

Partners in R&D Management Training

Based on the success of the manual in Series I, it appears that these strategies are successful, and that we can expect demand to increase for RDI management training provided by instructors who are trained to use these Manuals. We also expect an increased de-
mand 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

Purposes and Contents of the Manual

This manual focuses on the management of facilities and materials. It is targeted on R&D managers at both the strategic and operational levels of the RDI. This Series II Manual is aimed at all potential RDI users, considering that people can be trained to be more sensitive to institutional requirements and can indeed initiate some of the changes that will lead to more productive R&D management. It is related to the Manual in Series I, but it can be used as a stand-alone Manual.

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 how their decisions about facilities and materials should be related to the strategic goals of the RDI;
2. Relate similar problems in areas such as equipment and materials;
3. Develop a sound integrative philosophy of all areas covered;
4. Improve their knowledge or learn about concepts and techniques used for facilities and materials management;
5. Apply their learnings to their own RDIs.

The manual is divided into nine parts, as follows:

INTRODUCTION

CHAPTER I Strategic Facilities and Materials Management
CHAPTER II Overview of Procurement
CHAPTER III Equipment
CHAPTER IV Materials
CHAPTER V  Land
CHAPTER VI  Buildings

GLOSSARY

BIBLIOGRAPHY

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 mediated instruction in a workshop setting.

Most problem areas revealed during fieldwork were neither common to all RDIs nor existed to the same extent in those RDIs which had them in common. Therefore, it should be recognized that it is not easy to cover all areas in both the depth and scope that would make such a Manual an all encompassing one for each individual RDI manager: at the outset, this Manual was not intended as an all-inclusive textbook, but rather as a useful and practical one for all participants. A bibliography at the end of each chapter allows the reader who wants further details, to find the required information.

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 this manual and the preceding one:

1. **Mediated and Self-Instructional:** The manual must be amenable to stand-up 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 concepts 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 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, which we believe should be visually pleasant and useful.

The fourth criterion, interactive, stems from a sense that RDI participants fail to see the value of 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 from another. Finally, it is sometimes believed —wrongly—that large RDIs have little to learn from smaller RDls.

Therefore, it is important for the Manual to demonstrate that all trainees have a great deal to offer each other. It must stimulate them to share and solve their management problems together. In fact it is possible and desirable to learn from the experience of others; this is why one should be open to the numerous ideas and concepts which can be transferable to one's own RDI. 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 others' ideas and solutions to management problems.

The fifth pedagogical criterion, empirical, stems from the feeling that attempts to transfer management technology from business schools or RDls 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 cannot be applied directly in a developing country context. Therefore, the manuals must present management 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.
2. The mandate statement for the institution they represent.
3. The current organization chart for their own institution.
4. Examples, from their own institution, of R&D proposals, budgets, records, and practices.
Many of the exercises in the Manual call for the participants to apply facilities and materials 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 three countries prior to outlining the parameters of this Manual. Furthermore, their observations are integrated in the body of the text so that trainees can see how the management concepts relate to real experiences. Finally, the whole Manual was critically reviewed and evaluated by a team of 12 R&D management specialists from 4 Third World countries. They suggested improvements which made this text even more customized for you.

3. Instructions for Users

Introduction: This manual is part of Series II called R&D Institute Facilities and Materials Management. Its key purpose is to enhance your R&D management skills in the area of facilities and materials. It has been designed to provide users with 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: Most chapters contain 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; overnight as homework during a mediated workshop; in teams during class time; or even in plenary. In many cases exercise answers are provided later so that R&D managers may check their work.

Outline of Procedures Manuals: There are procedures outlines for all chapters, but the first one. These outlines appear at the end of the chapters and aim at providing an overview of the important aspects to be considered in relation with the topic covered in the chapters. The procedures outline for buildings appears together with the one for land, due to the close relationship between both topics.

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 should be ignored. Otherwise, instructor(s) may find them helpful in organizing the workshop.

Chapter Guides: Each section is headed by three pages. These pages 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 the sections in each chapter. These numbers are designed to help you direct your study and discussion with other fellow-students.

Length of Sessions: Normally, a workshop planned for a group of R&D managers should include about 10 days of instruction. Some of the Manual chapters comprise one-day sessions. Others are two-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 most 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. Furthermore, the typing font changed between columns. Here is why.

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 and will be able to apply your learning in your work or in your personal lives. 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 provide a basis for answering them. So if you have difficulty with them, you will have no trouble finding out where to go for help. The instructor(s) and other group members will be referring to highlighted sections or cases to support their comments. These highlight sections are termed “cases” and are described later in the course. Each “case” is a description of real RD 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 flavor 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 materials, 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.

We 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 underlined. Finally, we have included a GLOSSARY of over 80 words which will also help you adjust to the language. In many instances, we have voluntarily provided somewhat different definitions in the text and in the glossary, in order to allow you to choose the definition you prefer, i.e. the one that is easier to understand.

Boldface Text: We also use the boldface text to emphasize one key idea throughout this Manual. If nothing else, we sincerely hope that all participants exit this course of instruction with renewed appreciation for the role of facilities and materials management in attaining R&D main goal, namely the enhancement of national development.

Above all else, we want all participants to reorient all of 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 will also bear a person’s name in parentheses. This is a bibliographical citation. It means that the idea immediately preceding this citation came from another author. You may discover the original source of the idea by looking for that author’s name 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. Most of them are briefly reviewed for you. This was done to provide you a wider orientation to the literature so that you may pursue any topics on which you would like more information.

However, you will also find selected readings at the end of each chapter. These are the books and articles which are more directly related to the topics included in that chapter.

**Summary:** Good luck and enjoy your experience! 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.
CHAPTER I

STRATEGIC FACILITIES AND MATERIALS MANAGEMENT
Training Objectives

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

1. Define national development.
2. Explain national development planning.
3. Understand the relationship between R&D management and national development.
5. Explain some of the characteristics of facilities and materials management.
6. Justify the importance of facilities and materials management.
7. Understand the implications of strategic as well as of operational aspects of facilities and materials management.
STRATEGIC FACILITIES AND MATERIALS MANAGEMENT

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All of this material can be covered in one session, if it has been studied on an individual basis prior to the session.
CHAPTER 1

STRATEGIC FACILITIES AND MATERIALS MANAGEMENT

1.111 Introduction: Section 1.1 of this chapter provides an overview of Series I Manual on Strategic Planning and Budgeting. Such an approach is used in this Manual, and will be used in forthcoming Manuals, because Series I Manual represents the foundation of this series. This overview is also useful as an introduction to Facilities and Materials Management, the core topic of this Manual.

1.121 National Development: At the outset, the country offers vital national resources (personnel, facilities, expensive equipment, real property, money) for some kind of activity known as "research and development" (R&D). Then, after that activity is completed, the country looks for significant improvements in vital sectors of the economy.

1.122 Definition: National development is the process that ensures the most equitable positive change in these factors for all elements of society. Governments of developing countries have goals, policies and criteria for ensuring national development. They are usually embodied in national
development plans. A **National development plan** is an aggregate of sectoral and often regional plans that specify government development strategies for a given period of time.

1.123 In the science and technology sector, research and development (R&D) is generally recognized as the most important tool to attain national development. Thus, R&D should be understood as a catalyst for national development. In that role it often serves as a prerequisite to sound planning and policy evolution by providing new options to help revise old and accepted practices. In this and in other manuals, R&D means:

An investigative and adaptive process using a wide range of methods for deriving and applying knowledge to enhance national development.

1.124 The special nature of R&D argues for special facilities and organization, thereby making necessary entities known as R&D institutes, or RDIs.

1.125 In effect, an RDI is an operational instrument for achieving the development goals of government. Its mission is to fulfil those development goals which apply to its sector and resources. There are often conflicting objectives among and even within departments: this is why it is important to make the appropriate choices, based on the key objectives of the RDI.

1.126 There are often discussions regarding the goals of mission-oriented and client centered RDIs. Ultimately, the distinction between them reduces to a distinction of client accountability. The former are not often accountable to the ultimate users of technology. The latter are more accountable.

1.127 As a consequence, we, in this and other FAMESA Management Manuals for Productive R&D, refuse to use this distinction. Instead, we focus on how to manage R&D institutes (RDIs) so that they actually produce technologies which actually have some desired effect on national development.

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**In a few words, what is the national development plan regarding the sector of the economy that your RDI is in?**

---

**Can you name 5 RDIs other than your own?**

(1) ____________________________
(2) ____________________________
(3) ____________________________
(4) ____________________________
(5) ____________________________

**What are the common aspects among them?**
1.128 In fact, R&D becomes "productive" when it provides reliable solutions to key development problems. All RDIs have this need. And whether they answer primarily to government or businesses in the private sector, all RDIs can become more productive. Do you agree?

1.129 Scientists as a whole, and applied researchers in particular, have a duty to ensure that they deliver useful technology. On them rests the responsibility to convince policy makers and financial allocators that R&D benefits national development. R&D results must be convincingly presented so that they enhance mutual understanding and confidence in the role of R&D in national development. It is only in a climate of confidence that scarce financial resources will continue to be allocated to R&D.

1.131(a) R&D Management: R&D management is defined as the efficient and effective mobilization, 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. Therefore, sound management results into effectiveness, efficiency and prompt achievement of intended goals.

1.131(b) Efficiency usually implies both speed of execution and parsimony in the expenditure of money and other resources. For instance, actual results can be compared to budgets. Quite obviously time and resources become critical elements of the R&D management process. This is why it is important to manage with a constant preoccupation for efficiency and effectiveness.

1.131(c) Effectiveness usually means that a person, thing, or process actually accomplishes intended results. The distinction between efficiency and effectiveness is represented in Figure 1.1. High technology and good resources management should be effectively employed so as to reduce the costs involved. Thus, the utilization of these resources must be productive in order to achieve the objectives set.

It would be useful to re-read this fundamental definition at least once again.

Provide an example of an operation which is efficient but not effective. How do you know that it is not effective?
Figure 1.1. Distinction Between Efficiency and Effectiveness

1.131(d) Control is the process of deciding how to change the rate of resource absorption, or technical work, in order to obtain the greatest project efficiency and effectiveness. Therefore, management control of R&D requires a very sensitive, if firm, hand on all activities in the RDI.

1.131(e) Resources include:
- Trained personnel;
- Money;
- Time;
- Energy;
- Raw materials and supplies;
- Instrumentation and equipment;
- Buildings; and
- Land.

This explains why this Manual comes immediately after Series I Manual!

Do you know other resources?
1.131 (g) The techniques for managing resources vary with the nature of the resource, among other things. As a consequence, R&D management includes a variety of resource management technologies; hence, different managers are frequently assigned to different resources.

1.131 (h) It is the astute management of resources which goes the furthest toward ensuring the productivity of R&D. Resources fuel the R&D process; without them the process dies.

1.131 (i) Technology is used, here, in a most general sense. It refers to the science of controlling forces, both natural and social, to produce desired effects. Control is key to the purpose of RDIs. It’s also key to managing productive R&D.

1.131 (j) RDIs are designed to help society learn to control the forces which impact it. Technology is the collection of knowledge and processes which give society that leverage. Technology is the sometimes elusive target of R&D.

1.132 The exercise of R&D is expensive. However, R&D management remains one of the least developed capabilities in the R&D enterprise, although it is most essential. Most professionals approach R&D with advanced training and experience in the subtleties of science and technology. Few of them will have experienced appropriate training on the principles and practices of sound management in any enterprise. Most of them will have acquired these only through experience, to the extent they know them at all. But what happens when the RDI administrative superstructure not only controls resources for their work, but also their technical goals and priorities?

1.133 (a) Therefore, researchers might experience problems in terms of managing properly. However, R&D managers are all the people in the RDI — not only those whose job descriptions include more management functions than scientific or technical ones — because each

Is this your case? Does this description correspond well to your RDI?

Answer this question right now: it concerns you directly.

There is one saying in organizational behaviour which says that “If you treat people like professionals, they will behave like professionals”. Do you think that it is true if we replace the word “professionals” by the word “managers”? 
person is responsible for some aspects of management in the RDI. Therefore, everybody could benefit from proper management training.

1.133(b) In order to improve management skills in the R&D management area, it is important that the institutions formulate appropriate training policies such as internal or external workshops. Workshops such as the ones through FAMESA represent a good example of proper management training.

1.134(a) It is commonly accepted that management is both an art and a science. This series of Manuals presents philosophies, concepts, and techniques which demonstrate that management is a science, and thus that it can be learned.

1.134(b) Therefore, the purpose of this training material is to stimulate sound management practices among all functional elements of the RDI. We also feel that it is more useful to provide management training which is more specifically adapted to the special character of management in an RDI.

1.135 An RDI is a social system in which strategic managers, researchers and support staff work and interact. Without R&D or if the R&D activities are not productive, there is no purpose for the RDI.

1.136 R&D management is nothing if it is not a holistic process. Each topic depends for its success on the successful practice of every other topic. Management includes organizing, planning, budgeting, proposing, and controlling. These elements, which can be visualized in Figure 1.2, are covered successively in the following subsections.

1.141 Organizing: An organization is the structure of relationships, among personnel, financial and material resources, that are designed to accomplish a specific set of objectives. In an RDI, organization is the structure of relationships among strategic managers, researchers and support staff, all of whom are bent on the accomplishment of a variety of R&D objectives.
1.142(a) Experience in RDIs and a variety of other organizations has yielded eight principles of organization which help in the design of the most efficient and effective RDI:

- Continuous chain of command: all responsibilities and authority should flow smoothly from the highest to the lowest organizational level;
- Unity of command: each member of the RDI should report only to one superior;
- Short chain of command: the number of distinct management levels should be kept as small as possible;
- Span of control: a manager can supervise effectively only a small number of persons;
- Exception principle: recurring decisions should usually be made at lower levels of management;
- Division: the structure should contribute to a great effectiveness and efficiency;
- Balance: the size of the units should allow for comparable performance capacities;
- Delegation of authority: the degree of delegation really depends on the management style of institutional directors.

Do you know what they mean? All these principles are covered in more detail in the Series I Manual. Refer to that Manual if you need additional explanations.

1.142(b) This last principle refers to the way decisions are made by management. In a centralized structure, all decisions are made by
the highest level managers. But in a decentralized structure, responsibility for decisions is delegated as far down the organization as possible.

1.143 There are three general organizational designs:

- Functional: the units of this organization are defined in terms of special skill areas like finance, procurement, etc.;

- Project: the units are defined in terms of the technical objectives of the RDI; in this type of organization, units often correspond to individual projects;

- Matrix: this type of organization combines the other two types: one dimension is functional, and the other, matrix.

1.144 As an RDI becomes more project oriented, greater flexibility results; whereas more stability (with the danger of becoming static) can be found in functional organizations. Therefore, a sound RDI needs both the pyramid hierarchy of a functional organization, and the capacity to organize project teams on both a temporary and permanent basis. This is the purpose for which the matrix format was designed.

1.151 Planning is the process of making decisions about what is to be done; why; for whom; how; by whom; with what resources; and when?

1.152 Basically, it is the attempt to predict, before any work is expended, exactly what will be known after the work is done: the technical results; their cost; the methods of achieving them; and the resources required to achieve them.

1.153 In the case of R&D management, planning should be regarded as “drafts” of the way things are expected to go. The results of strategic planning lead to a collection of statements called “RDI Policies”. Actually, planning in an RDI has different characteristics for different kinds of R&D projects, whether they be basic research, applied research, adaptive research, or development.
1.154(a) It is important to note how strategic and project planning relate to each other. Usually an RDI gets started when someone in the government realizes that some kind of R&D would enhance development in the country. But it is not a short leap from that idea to an effective research project.

1.154(b) Usually some kind of organization must be formed to oversee the research. Buildings and other facilities must be developed. Equipment and supplies must be obtained. Various kinds of personnel must be located, recruited and hired. And, all of these resources require financial commitments from government.

1.154(c) Resources are vital elements of planning at both levels. At the project level they should be very detailed. The project plan should show the facilities, equipment, raw materials, money and personnel needed; per research task, and per unit of time. Such precision is required in order to control the expenditure of all these vital and limited resources. In fact, control is the name of the planning game. We plan our R&D so that we may obtain the results needed, within the given resource constraints.

1.155(a) All R&D plans have more or less the same components:

- Goals and/or objectives;
- Activities and/or tasks;
- Methods;
- Schedules;
- Resources needed;
- Management techniques.

1.155(b) Six techniques could be applied to projects, to a collection of projects which comprise an R&D programme, or even to an RDI (many R&D programmes) in strategic planning. They are:

- Task lists;
- Bar chart;
- Deliverables chart;
- Critical Path Method (CPM);
- Programme Evaluation and Review Technique (PERT);
1.156(a) Tasks, time and costs are the three principal elements of any planning exercise. Planners try to anticipate what will be done; for how long; at what cost? These same factors comprise the principal elements of monitoring and control, as well.

1.156(b) In fact, there are four axes along which it is possible to analyse any project and to divide it up into its component parts. These axes are due to the fact that a project:

- Is technically discrete;
- Is temporally discrete;
- Is financially discrete;
- Yields discrete results.

1.157 So the point is: Plan, but with realistic expectations of the plan accuracy. Plan, but with tolerance for the certain need to change those plans. Plan, but recognize that its results are far poorer guarantors of R&D success, than the planning process itself.

1.158 The next section deals with budgeting, which of course relates to financial resources. But it is vital to acknowledge that all the other resources must be bought, built, maintained, operated and replaced. All of these operations require money.

1.161 **Budgeting** is the process of anticipating the financial requirements for R&D. It requires very deliberate and careful planning and scheduling of all project tasks and resources.

1.162(a) R&D budgets are merely estimates to be used as guides, not rigid limitations. At the strategic level, the budget is developed (usually) once a year and it remains fairly stable. At the operational level, however, budgets are reviewed at least quarterly and frequently revised as often.

1.162(b) At the strategic level, budgets are used to acquire finances from government, whereas at the operational level, they are used to anticipate and control expenditures. Therefore, budgets

Think about the last important planning meeting or discussion you have been involved in. How were tasks, time and costs covered? How do these elements relate to each other? (Clue: think in terms of tradeoffs between time and costs).

What are the practical implications of each of these possible divisions?

Why is it so if the budget is developed usually only once every year at the strategic level?
should be made as if funds would be available.

1.163 After the initial planning period, the budget helps control research by providing control points and forcing reviews of projects; keeping research managers money conscious; and keeping total research expense in line with budgeted expense.

1.164 Thus, the periodic reviews of R&D budgets contribute to more careful research planning and higher research productivity. Therefore, the budget cannot set standards for measuring the efficiency of R&D work. The budget measures planned effort, not achieved results of R&D.

1.165 Key actors in the budgeting process are the RDI director, financial and technical people. But in the last analysis, the success of this whole operation depends on the coordination and cooperation shared by RDI managers with people at all levels.

1.166(a) The RDI exists to produce new technologies which enhance the country's development potential. It is effective if it does so within realistic resource parameters. It is not, if it does not. Therefore, every decision made in the RDI must be tied to considerations of its impact on R&D productivity.

1.166(b) That is why it is necessary to have all the following elements in support of every R&D project and programme cost proposal:

- Cost estimators;
- Task list;
- Cost categories:
  - Personnel
  - Salary increases
  - Fringe benefits
  - Special services
  - Service costs
  - Insurance
  - Equipment
  - Maintenance
  - Materials and Supplies.

This distinction is important. Make sure you understand it well.
1.166(c) However, the purchase of capital equipment should be accompanied with studied consideration of maintenance and replacement parts and supplies to keep the new hardware functioning smoothly and efficiently.

1.166(d) We have visited many RDIs which operate under a government budgeting policy that separates personnel and other institute operating costs from the direct costs of R&D projects.

1.166(e) This is directly opposite to the approach we are taking in this workshop. Here we are emphasizing that the sole purpose of R&D management is to enhance R&D productivity for the sake of national development.

1.166(f) As a consequence we are assuming that RDI managers do want to account for RDI costs on the basis of R&D productivity. Hence it is necessary to monitor all R&D-related costs, including labour and other operating expenses.

1.167(a) **Indirect Expenses:** Indirect costs are those which are incurred by the RDI but which are not directly attributable to the requirements of projects. Indirect costs are considered controllable costs. Indirect costs include, but are not limited to, such items as dues and subscriptions, library costs, maintenance expenses, general operating supplies, routine raw materials, routine travel, telephone expenses, and so on.

1.167(b) Indirect expenses are incurred as a function of the work, R&D projects and programmes, of the RDI. This is in contrast to a group of expenses called “overhead”. They are real costs; but they would exist even if the RDI did no work at all.

1.168(a) **Overhead Costs:** These are the cost of staying in business: the cost of running the RDI. They exist because the RDI exists. Frequently they are the costs encountered to own and operate the R&D facility, regardless of R&D productivity. They too are indirect costs in that they cannot realistically be charged to any single project as a direct expense. However, without them, the RDI would be forced to close.
1.168(b) For example, they include such items as rent on property and buildings; depreciation; insurance; utilities, and allocated facilities costs. Certainly these expenses contribute significantly to the RDI's overall financial status. This has to be monitored and controlled by someone.

1.168(c) An overhead allocation rate is determined by dividing the overhead cost (for example, last year's overhead cost total) by the total labour hours or costs for the same period.

1.171 Proposing: The project proposal is a statement of justification for the objectives, methods, resources and management of an R&D project. It has many uses. At the project level it informs all project personnel about the purpose of their efforts.

1.172 An R&D plan is a logical statement of the sequence of events leading to the accomplishment of specific technical objectives.

1.173(a) 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, namely R&D productivity for national development.

1.173(b) One consequence is that all project proposals, plans and reports have in common a status report on the project's relationship to that overriding concern. The proposal tells how the project is expected to enhance national development needs; this portion is often called the "statement of project goals".

1.174 We propose the following thirteen basic topics for inclusion in an R&D project proposal:

1. Statement of the problem and intended uses of the proposed technology;
2. Goals of R&D;
3. Project justification;
4. Scope and limitations of the project;
5. R&D methodologies and procedures;
6. Role of project beneficiaries;
7. Scheduling and summary of workplan;

What do project proposals look like in your RDI? Whom are they presented to?

How does an R&D plan relate to the "planning" step already discussed?

The first 12 topics have been grouped 3 by 3, which is a coincidence. What is the common relationship shared by each of the 3 topics in a group? In other words, what general headings would you give to topics:

1, 2, 3: ____________________
8. Facilities, organization and personnel;  
9. Budget;  
10. Expected outcomes of the project;  
11. Dissemination and transfer to beneficiaries;  
12. Other pertinent information;  

1.181 Monitoring and Control: Monitoring an R&D project is the process of observing project progress and resource utilization, and anticipating deviations from planned expectations. Controlling, on the other hand, is the process of making adjustments which correct for the deviations from planned progress.

1.182 Plans and budgets are designed to help RDI managers expect productive R&D. Monitoring and controlling project implementation help them realize their expectations (or, occasionally change these).

1.183 In the case of monitoring and control, it means that all tasks of the project (technical performance), were completed on time (schedule performance) and within resource constraints (cost performance).

1.184 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 is also revised to reflect the most realistic expenditure of available resources. As soon as working plans and budgets are completed, the project technical, schedule, and cost parameters are set.

1.185 R&D people are not different from all others. They like to take pride in their work—particularly since it requires so much creative energy. As a consequence, they must feel like they have some control over their work—that they have a significant amount of influence over what they do.

1.186(a) Organization lies at the heart of any RDI's success in planning, budgeting, monitoring or control. The secret for all these techniques is to conduct them in a manner which ensures the
productivity of R&D projects, programmes and people. Too often, RDI's get caught up in an organization structure which is designed to perpetuate management.

1.186(b) One way to safeguard against this eventuality is to keep management responsibility, and the tools that go with it, in the hands of the R&D project technical managers. All RDI non-technical management personnel, should be at the service of R&D technical people. Too often, the reverse happens; RDI managers begin to think of technical people as servants.

1.186(c) It is a difficult, but vital balance which must be struck. Effective RDIs are those in which most resources, roles and responsibilities are vested in R&D project and programme leaders. After all, these are the people who play the most direct role in generating the output of the RDI.

1.211 Facilities and Materials Management (F&MM): This section deals with an overview of the topic in the title above. It will allow to integrate — at the same level — this topic with section 1.1 on planning and budgeting.

1.212 Definition: Facilities are all physical resources having a useful life exceeding one year, and which are necessary to operate an RDI. These resources, which should be adequate in order for the RDI to operate properly, are land, buildings, and equipment. Figure 1.3 illustrates the role of resources in the transformation process.

1.213 Definition: Materials are items and substances which can be considered as inventories once they are acquired. Materials may be used directly in the core activities of an RDI, or may contribute indirectly to their realization. Chemical products fall into the first category, while oil falls into the second.
Figure 1.3. The Role of Materials and Facilities in the Transformation Process

1.214(a) The representation of RDIs as organizations with tangible or intangible outputs, makes it easier to visualize how resources contribute to the success of RDIs.

1.214(b) A tangible output is one which is visible, e.g. it can be touched and seen. For instance, a report or any type of visible product is tangible. However, the study or the research leading to the report or the product is intangible, e.g. it cannot be seen. Actually, what can be seen are indeed the activities leading to the tangible output.

1.214(c) Most RDIs have a highly intangible output, because research activities are performed, and few tangible outputs are obtained. However, the results of research can be very useful to the country and yield, at a later stage, tangible outputs such as more resistant maize.

1.221 Need for Training in Facilities and Materials Management. This manual is the result of fieldwork performed by local experts in the field, under the guidance of the FAMESA coordinator. They visited 12 RDIs in 3 countries. Their observations and recommendations served as a basis of orientation to the author of this Manual.

1.222 Their overall impression leaves no doubt as to the importance of this Manual. Many RDIs have to operate under serious financial and
resource limitations. Managers of these institutions need to address themselves to these issues in an attempt to improve their existing systems or to set up new ones. In some cases, facilities and materials represent an important portion of their budget, a consideration which makes improvements even more imperative. Therefore, the Manual should be endorsed by the policy-making organ of the RDI.

1.223(a) In many RDIs, there was an obvious lack of formal training in all areas of Facilities and Materials Management (F&MM). Despite the fact that staff were often aware of the seriousness of many of the problems, they could not solve many of these due to inadequate knowledge or severe financial constraints. This Manual — like the ones in other series — can help to alleviate both types of problems: it provides some knowledge which makes it possible to manage better, with the result that savings realized can be used for other purposes.

1.223(b) Despite the positive impact of good training on proper and effective management, there was a lack of training in most RDIs. The type of training required included knowledge and understanding of procedures, techniques and approaches useful in F&MM. Many of these are developed in this Manual.

1.224 There is also a tendency to neglect F&MM, because it is not at the heart of the main purpose of RDIs. However, this approach neglects the positive impact that proper management can have on the efficiency of the research aspects of an RDI.

1.225 In fact, the opposite approach should be used: focus enough energies to improve the management of F&MM so that not only will it not hinder the core operations of the RDI, but it will contribute to their success. It is always possible to provide a better support to the core activities of an RDI at a lesser total cost, as pictured in Figure 1.4.

What percentage of your RDI budget do facilities and materials represent?

Does this description fit well with the present situation in your RDI?

Case # 1.1: An agricultural research station is highly technically advanced. However, facilities and materials management has been neglected to the extent that:

- Stores were congested;
- Stores records were inexistent;
- Poisonous chemicals were not properly isolated;
- Reorder points and reorder quantities were not known;
- Personnel was not trained in inventory control;
- No written purchasing procedures existed.

Which of the 2 approaches correspond better to the situation in your RDI (Check where appropriate)

□ Neglect of F&MM
□ Much efforts in F&MM
Figure 1.4. Impact of Facilities and Materials Management on the Efficiency of Core Operations

1.226 All RDIs are characterized by their fundamental goal of enhancing national development. They also have some individual characteristics such as the nature of their own operations, their location, and the type of people who work in the organization. Whenever possible, this RDI-customized Manual takes these differences into consideration.

1.227 However, despite the fact that RDIs differ from other organizations and among themselves, the basic principles of F&MM are generalizable. For instance, adequate maintenance of equipment is as important for RDIs as it is for other organizations. If some Japanese techniques have been successfully adapted to suit other cultures, why could not sound F&MM principles be adapted to RDIs on this continent?

1.228 It is of utmost importance that readers of this Manual do not limit their thinking by saying that what is good elsewhere will not work in their own RDI. It is likely that F&MM will not work exactly the same way as elsewhere for all principles and procedures. However, the knowledge, work, and ingenuity of RDI personnel should make it possible to determine whether to use as is or to adapt the F&MM concepts to suit the specific characteristics of that RDI.

1.231 Willingness to Improve F&MM: The capability to do many of the things required already exists. What is needed is the will to be actively involved in the process of either changing things or improving them. The application of
many of the ideas in this Manual would not involve considerable expenditures, but could help significantly RDIs. Some other areas necessitate a larger use of resources, because, in some cases, these areas have been seriously neglected in the past.

1.232 This Manual on Facilities and Materials Management will be useful mostly in the RDIs where there is a firm commitment to improve this aspect of the efficiency of operations. Like for everything else, when insufficient efforts are done, the situation tends to deteriorate over time. Paying lip-service only is not sufficient to obtain results.

1.233 Researchers could be among the most eager defenders of improvements in F&MM, if they see clearly the benefits for their research. Furthermore, their technical background could help in applying these concepts logically.

1.234 Economies stemming from improved F&MM could represent net savings of at least 5%, if not 10%, of the entire RDI budget. These savings should materialize in RDIs where facilities and materials management has been neglected, although this area represented at least 25% of their budget.

1.235 The savings just mentioned correspond to an annual increase of an RDI budget by the same amount. It is important that governments do not penalize more efficient RDIs by reducing their budgets accordingly. Therefore, there should be external but also internal incentives to improve operations.

1.236 The relative absence of direct competitors might sometimes reduce the incentive to improve F&MM. However, it is believed that the desire to improve RDI management in general is pervasive enough to be optimistic about the use of many more sound concepts of F&MM.

1.237 In fact, Facilities and Materials Management is much more than a group of techniques: it is a philosophy, and should be seen that way. Accordingly, it should become prevalent everywhere in an RDI, and be used as a guideline.

F&MM = A PHILOSOPHY
Like some RDIs have already demonstrated in particular areas, there is no reason why, in the long-term, F&MM cannot reach a level that would also be considered satisfactory in other parts of the world.

Strategic Facilities and Materials Management: Adequate F&MM does not simply happen. It must be planned, organized, and controlled. The structure and procedures should also fit the objectives set by top RDI officials. In order to do so, the major strategic orientations and operational guidelines of the RDI should be clear to all those working in the RDI.

As shown by Figure 1.5, the RDI strategy provides an orientation to the Operations strategy, which in turn limits the alternatives available for F&MM. It is in this context that F&MM should be seen, not with an independent managerial perspective. In fact, all sub-systems such as scheduling, purchasing, etc., are interrelated. For instance, a decision to buy in larger quantities cannot be taken without proper consideration for storage space and funds available.

This overall "systems approach" illustrates that almost all decisions involve a strategic portion. Therefore, this observation is also true for F&MM: it is not only the daily operational details which are to be considered. The location of an RDI is a case in point.

If others can, why can't you?

Do you have another example in mind?

Why should a systems approach be used for the location of an RDI?

Figure 1.5. Adjusting Facilities and Materials Management Objectives to the Overall Strategy
1.244 Because land, buildings, equipment, and materials are resources which make possible the attainment of R&RD activities, they do not represent an end in themselves. They should be managed in terms of the fundamental goal of an RDI, national development. It is only this orientation which makes F&MM effective; all other orientations can only make it efficient.

EFFECTIVENESS = TO ORIENTATE RESOURCES FOR NATIONAL DEVELOPMENT.

1.245 Overall, it is necessary to make sure that the activities performed in an RDI be of the quality level aimed for. Proper management of the resources analysed in this Manual can contribute substantially to suitable quality.

1.251 Operational Considerations: Operations related to F&MM include a wide variety of topics. Few persons are very knowledgeable in all areas. The same is also true of any research area. Although it is not necessary at all to be an expert to discuss about and implement concepts in F&MM, it is recommended to ask experts to review all aspects of F&MM within a specific RDI. This step, called a facilities and materials audit, allows for an objective evaluation of the areas which represent the most potential for improvement.

This manual contains most of the issues and concepts likely to be raised by experts. Although it is not expected that RDIs will follow all possible procedures and controls regarding F&MM, there is no valid reason to argue, for instance, that few of these apply to small RDIs: what will happen when the RDI will grow? It will be more and more difficult to modify inadequate methods in use. Therefore, it is appropriate to adopt good methods and procedures as soon as possible.

1.253 When individuals—including the readers of this Manual—are exposed to concepts, cases, exercises, and eventually to discussions, they keep their minds opened for potential applications to their own RDI. Concepts are often put in concrete form only after extensive discussions.

Case# 1.2: An internationally-known RDI has an ongoing management audit for workshops and stores.

This audit is only a part of ongoing efforts to improve the functioning of the RDI and to assess how the state of various buildings, equipment, etc. were affecting the productivity of research scientists and the RDI in general.

The same reasoning is applicable for goods and services: it is preferable to do them right the first time.

The ultimate usefulness test for this Manual? The benefits that YOU and your RDI derive from this text.
1.254 It should be emphasized that it is usually not the most sophisticated methods and procedures of F&MM which work best. The principle is: the simpler, the better, as long as it works reasonably well and it is logical, so that it can easily be understood. Such an approach makes sense for all organizations, but particularly for RDIs, considering their problems in the area of F&MM. It is indeed much easier to improve operations when efforts are made to reach attainable goals, than better goals known to be too optimistic. For instance, it is sometimes more justified to improve a manual stock record system than to computerize it.

1.255 The management of changes in the area of facilities and materials shares some characteristics with most other changes. The most important one is the necessity to recognize that changes do not bring only technical problems, but also "human" problems. Both types of problems are better managed when they are expected and dealt with before, rather than after the fact.

1.256 Situations regarding facilities and materials often involve many RDI staff members. Therefore, they represent an excellent opportunity to involve these persons in the decision process. They are indeed the ones who have experienced most of the problems with the existing situation, and who will have to deal with those stemming from the changes made. Similarly, although RDI officials are sometimes better to seek external advice, they are best placed to implement the changes.

1.257 It is often appropriate to begin with changes which are the most likely to succeed, and which are highly desirable for all those concerned. This approach has the advantage to demonstrate clearly the potential benefits for all of improving a given situation.

1.258 Fortunately, F&MM offers many such opportunities. For instance, a few minor repairs to a building and subsequent adequate preventive maintenance are easy to see, and contribute to pass a clear message as to the new F&MM philosophy. This philosophy will have its first real test when
some persons will want to go back to previous methods or procedures. However, changes should be so useful, that nobody will resent them.

1.259 Finally, the changes should be planned. Therefore, there should be a schedule and a clear order of priorities set by officials. Continuous useful improvements are possible and desirable in the area of F&MM.

1.261(a) Conclusion: This chapter dealt with two major themes: an overview of the Series I manual on Strategic and Project Planning, and Budgeting and general considerations on the theme of this Manual.

1.261(b) The notions of National Development and R&D Management were initially developed. Then each of the five components of management were briefly covered: organizing, planning budgeting, proposing, and monitoring and control.

1.261(c) Then, proper background information such as the importance of F&MM, the approach used in this Manual and the systems approach were developed.

1.262 The following chapter covers aspects of procurement which represent important considerations for R&Ds. Chapters III to VI deal successively with equipment, materials, land, and buildings. Aspects covered in this chapter should be kept as background information during the reading of all these chapters. The systems approach is already at work!
CHAPTER II

OVERVIEW OF PROCUREMENT
OVERVIEW OF PROCUREMENT

Training Objectives

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

1. Know the main objectives of procurement.
2. Determine the impact of organizational design on procurement.
3. Understand the importance of procurement procedures.
4. Know some of the key procedures.
5. Explain what to consider in the selection of the sources of supply.
6. Identify how prices are determined by suppliers and the influence of buyers thereon.
7. Relate inspection procedures to quality and control.
OVERVIEW OF PROCUREMENT

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All of this material can be covered in one session, if it has been studied on an individual basis prior to the session.
CHAPTER II

OVERVIEW OF PROCUREMENT

2.111 Introduction and Key Objective: From a strategic point of view, procurement helps to realize economical and national objectives by providing the items and the services required for doing the RDI activities.

2.112 This chapter deals with overall aspects of procurement objectives, activities, and procedures. At the end of this chapter, an outline of purchasing procedures is provided to allow the reader to grasp easily all the steps involved in purchasing. Some specific aspects will be discussed in Chapters III and IV.

2.121 Definition: Procurement is an activity which deals with purchasing (including supplier development and negotiation with suppliers), stores, inspection, transportation, and disposal. Therefore, it is much wider in scope than purchasing, although this latter activity usually represents the largest portion of procurement activities. This is why the term "purchasing" is used most of the times in this text, when we refer to the acquisition phase only.

2.122 Top RDI officials should establish the role, priorities, and responsibilities of the purchasing
department. When overall RDI objectives are clear, it is likely that its role will also be clear. There is a huge difference between a department which is oriented mostly to fill out orders, and one whose mission also includes continuous research for price trends and for better suppliers. In fact, much efforts and money can be saved through sound procurement activities.

2.123(a) The key objective of procurement is to provide to an organization the items needed at the right price, where (location), when (time), and in the quantity and quality desired.

2.123(b) Obviously, as Figure 2.1 shows, the components—or sub-objectives—of this key objective involve tradeoffs. For instance, it is impossible to get always the best quality at the lowest price. Admittedly, there is actually not much tradeoff in terms of location, as goods have to be brought at a specific point.

Figure 2.1. Key Objective of Procurement

<table>
<thead>
<tr>
<th>PRICE</th>
<th>LOCATION</th>
<th>TIME</th>
<th>QUANTITY</th>
<th>QUALITY</th>
</tr>
</thead>
</table>

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2.124 The priorities among these sub-objectives are not the same for each RDI, mostly because the nature of their activities differ. However, these priorities must be clear to all, although they vary from one item to another. For instance, while certain chemicals are absolutely necessary, others might not be as essential. In the first case, there must be no stockout, while in the second case, it might be tolerable to be without one of these chemicals for a few days.

2.13 Suppliers can contribute substantially to the extent of the success of a procurement department in achieving the sub-objectives mentioned above. This observation explains why it is preferable for an RDI to maintain good relationships with suppliers.
2.141 Developing good relations with suppliers provides a good example of proactive management as opposed to reactive management. A proactive purchasing department puts emphasis on trying to improve all existing procurement aspects rather than on waiting that situations simply occur.

2.142 Such an approach makes it more significant to set targets such as reducing the average order processing time from say, 10 to 9 days. It also helps in coordinating the budgeting and purchasing functions. This coordination is important when one considers that a budget is an allocation of funds, and that purchasing is usually the main user of funds. It should be noted in passing that purchasing is often the department which can contribute the most to increase savings due to efficient operations.

2.143 Purchasing can also contribute to the efficiency of all departments by satisfying their needs, taking into consideration RDI constraints. Organizational aspects of a purchasing department influence its own efficiency and RDI's efficiency too. This aspect is covered in the next section.

2.21 Organization of Procurement: At the outset, it should be recognized that the objectives mentioned in the preceding section have to be carried out by people organized in a systematic manner. This organization of the procurement activities plays an important role in the efficiency and in the effectiveness of an RDI.

2.221 Most departments are involved in procurement. This comes as a consequence of all the steps necessary to fulfil a need expressed by a user. Therefore, the existence of a single purchasing department does not indicate that only one department is involved. It indicates rather that a number of activities have been grouped under an administrative division called “purchasing department”.

Overall, how would you describe the relations between your RDI and its suppliers?

Are there such objectives in your RDI?

Considering the definition of effectiveness mentioned in Chapter 1, how can a structure called “organization” influence effectiveness?
2.222 In fact, a purchasing department is important enough to be staffed with well qualified and experienced people. It is a specialized department and the ability of staff to work in other departments does not guarantee that they will do a good job in the purchasing department. It should be remembered that an efficient purchasing agent can save many times his salary in a single year! In itself, this is a sufficient reason to manage this department properly, beginning with appropriate staffing.

2.223 The purchasing function represents all the procurement activities performed in an RDI, whether they are performed by the purchasing department or not. The allocation of these activities among all departments represents an important decision, particularly in terms of control and procedures.

2.231 **Centralization or Decentralization?** As it has been mentioned in Chapter I, an organization is a means to structure activities in order to make them efficient. Procurement activities should allow an RDI to run smoothly. The key activities remain the research ones, and all other activities should be organized around them.

2.232 There are three main types of organizational designs for a purchasing department:

- By function;
- By region;
- By product type.

Figure 2.2 illustrates those three frequent organizational designs.

2.233 A functional organization is divided along the nature of the activities allocated to the purchasing department. For example, tasks could be divided up into local buying, overseas buying and transportation services. Naturally, it is expected that there will be collaboration among all persons concerned.
2.234 An organization by region recognizes that there might be advantages in allocating tasks along the geographical location of the user department. Obviously, this is applicable only to RDI's with more than one site. For instance, one buyer could be responsible for the southern part, while another one would make the transactions for the northern part.

2.235 Finally, a division by product type recognizes that it is preferable to allocate responsibilities based on the nature of the items to be purchased. For instance, the tasks related to the purchase of equipment differ substantially from those for the purchase of a chemical used regularly in the RDI.

Is it possible to integrate properly the 3 types of organizational designs? If so, how? If not, why not?

Figure 2.2. Organizational Designs for a Purchasing Department

By function

- Top official
- Local buying
- Overseas buying
- Transportation

By region

- Top official
- Southern
- Central
- Northern

By product type

- Top official
- Equipment
- Materials
- Services

2.236 These organizational designs are closely related to the decision to centralize or not some or all of the procurement activities. This decision is fundamental for RDI's with multiple sites. The
next paragraphs deal only briefly with this issue, because it has already been addressed in detail in Manual I.

2.237 Centralization provides a better control of activities, because most purchases are made through one department. It is a design which provides a better purchasing power and standardization of items purchased. It also allows for more specialized tasks within the purchasing department, and is well indicated for international purchases.

2.238 On the other hand, decentralization usually reduces paperwork and accelerates order processing times, two considerations which please researchers. It is often recommended for items to be bought locally, and for increasing the motivation level of managers who are not on the main site of an RDI. In fact, it could increase substantially these managers impression of control over the operational activities of an RDI site.

2.241 In most organizations, there is presently a tendency toward centralization for services and goods that are used by more than one RDI site, and for which important savings could be realized or tighter controls exercised.

2.242 However, there is always the danger that a centralized purchasing department becomes too bureaucratic and inflexible, at the expense of the dynamism of all RDI people, including those in the purchasing department. This is why it is important not to put excessive emphasis on tighter controls and procedures.

2.311 Procurement Procedures can be defined as an accepted established way to acquire goods and services. These procedures can be written or verbal. Naturally, it is preferable to have these in writing, in order to improve the likelihood that a common set of procedures will be adhered to.
2.312(a) It might be tempting for some RDI managers to develop sophisticated all encompassing purchasing procedures. In fact, procedures are often seen as a panacea for all control problems over a certain type of activity, purchasing in this case. This perception is erroneous.

2.312(b) Complex and numerous procedures cannot cover all potential situations which might arise. Therefore, they represent a costly approach which does not even guarantee that they will be adhered to.

2.312(c) In fact, purchasing procedures should be kept as simple as possible for four basic reasons:

- Easier understanding by users;
- Better likelihood that they will be adhered to;
- Smaller cost;
- Easier updating.

2.312(d) Overall, simple procedures enhance the chances that the purchasing system will work properly. However, simplification should not be contrary to the effort to make the procedures as foolproof as possible. One way to do so, is by designing forms that make it obvious when one information is missing.

2.313(a) Basically, purchasing procedures are aimed at:

- Improving control over purchasing;
- Making learning and understanding of purchasing activities easier;
- Accelerating the purchasing step of procurement.

2.313(b) Purchasing procedures are more likely to be adequate if individuals writing and implementing these also consider organizational objectives, resources, and the nature of the activities of the RDI.

2.313(c) These considerations are necessary because procedures should not constitute an end in themselves; otherwise, the organization becomes overly bureaucratic. Procedures are ways to
achieve an objective, users satisfaction. Ultimately, this objective translates into contributing to national development. If organizational objectives are clear, this relationship is probably clear also.

2.314 Procedures should leave room for judgment by users as well as by purchasing agents. This is one of the key aspects which makes an RDI dynamic. For instance, it is not necessary for small RDIs to have exhaustive procedures, if the appropriate ones exist for most situations and personnel judgements can be highly trusted for situations where no written procedure exists.

2.321(a) **Manual of Procedures**: This type of Manual usually represents an important investment in terms of the resources required to write it up. It is much preferable to have a user-oriented Manual than an organization oriented one. In the first case, it takes into consideration users preoccupations, and is likely the result of extensive discussions with managers and staff. In the second case, the emphasis has likely been put on control, without appropriate consideration for users.

2.321(b) Obviously, for the manual to be effective, it MUST be issued by the policy-making organ of the RDI as the RDI's Standing Instructions.

2.322(a) Fieldwork revealed that there were written purchasing—and even procurement procedures in many RDIs, although they did not appear to be followed strictly. As a consequence, it was recommended to have understandable, practical and efficient procurement procedures which would be communicated to all those involved in procurement activities.

2.322(b) Due to their frequency, it was also suggested to put complete instructions in writing regarding receiving, inspection, and stores. This way, there would be a clear assignment of responsibility among personnel.

2.323 A Manual has the advantage to make the procedures uniform across departments and RDI units located on different geographical sites. It reduces the importance of procedure modifications.
by users over time. However, it is inappropriate to have very detailed procedures for a few aspects, and none at all for others which would benefit the RDI.

2.324 There is no point in having a Manual if the procedures in it are not adhered to. In some larger RDI's, there is an internal audit department whose role is to ensure that a variety of procedures, including those for purchasing, are followed. This approach should be used positively, i.e. with the intent to improve progressively the situation, rather than to punish those who do not follow procedures.

2.325 It should be recognized that it is the managers' responsibility to ensure that procedures are adhered to by their staff. However, in order to do so, they must themselves know and understand the purchasing procedures in the manual. It should not come to a surprise if most managers do not know well the content of their RDI purchasing procedures Manual. In fact, how often are such Manuals read?

2.326(a) Once it is recognized that procedures that are not followed are not serving organizational purposes, a great step has been accomplished. Whether a manual is used and adhered to constitutes the real test of the usefulness of a manual.

2.326(b) When personnel misunderstands procedures, the causes thereof should be determined and eliminated. Proper training could have reduced the importance of the problem in the first place. It is not a matter of forcing personnel to use certain procedures, but rather of explaining the "why" and the "how to" of these procedures, including where they fit in the global picture. The efficiency resulting from those procedures should be pointed out to trainees.

2.326(c) When procedures are wrong or do not keep pace with reality, it should be expected that they will not be followed. In fact, this is a good sign that personnel use their judgement rather than only follow blindly the procedures in the Manual.

What is the approach used in your RDI regarding procedures which are not followed?

What is the situation in your RDI? Why is it so?

There are 3 main reasons for which purchasing procedures are not adhered to. Which are they?

(1) ____________________________
(2) ____________________________
(3) ____________________________

What is the approach used in your RDI regarding procedures which are not followed?
2.326(d) Procedures are dynamic. Therefore, it is important that efforts be made by knowledgeable people in keeping the written procedures updated with what is best for the organization. It should be emphasized that it is much easier to add new procedures than to delete those which are no more useful, or to modify those in need of substantial modifications.

2.331 Local Purchases: Procurement procedures vary a great deal from RDI to RDI, as reported by fieldwork researchers. This situation is due partly to differences in RDI size and type of operations as well as to the level of knowledge and effort of RDI managers.

2.332 Usually, documents and goods follow a typical procedure depicted in Figure 2.3. A user fills out a requisition and sends it, to the stores for stock items, and to the purchasing department for special items (in some RDIs, all requisitions are sent to stores). In the case where the quantity on hand falls below the reorder point, the storekeeper sends a requisition to the purchasing department, whose personnel is the sole one entitled to issue a purchase order to a supplier. A copy of the purchase order is also sent to the user, to the receiving department, and to accounting.

2.333 The supplier then sends the goods requested to the RDI receiving department, where they are inspected. A receiving slip is issued and a copy sent to purchasing, to stores, and to accounting. In many instances, the user is notified verbally upon arrival of the goods. All items required by the user can be sent directly to him, as long as this is an authorized procedure. The balance is forwarded to the stores.

2.334 The supplier sends an invoice, which corresponds to a requisition for payment of the goods received. A check payment is made by the accounting department, once it is also authorized by the user and by the purchasing department.

2.335 The above procedure represents a typical situation. A number of variations to this process can occur, and be justified in the specific circumstances applicable to the RDI.

Sometimes, one even wonders if in each organization with a large number of procedures, each additional procedure shouldn't be accepted only if it would replace another one!

Case #2.3:
A large RDI with multiple sections has the following procedures for local purchases:

1. A scientist requisitions what is needed.
2. It is approved by the Programme Leader.
3. The Supplies Officer receives the requisition for verification, confirmation and action.
4. The Supplies Officer decides on where to purchase the item.
5. The Finance Office authorizes the purchase if funds are available.
6. The Supplies Officer issues the purchase order to the supplier, after appropriate approvals.
7. Goods are received by the Stores Officer. They are checked, verified and documented.
8. Non-stock items are sent to the requisitioning department with an accompanying issue note; stock items go to stores.

Why should it be authorized by someone in the purchasing department, considering that goods received have been inspected and approved?
2.341 **Overseas Purchases:** Basically, purchasing steps remain similar to those for local purchases. However, there are additional steps necessary. These steps can be quite complex. As a result, many persons interviewed during the course of fieldwork mentioned that overseas purchasing constituted an important challenge for their RDI. The challenge is even more substantial in the case of equipment, because of the value involved and due to the fact that it is often the only equipment purchase of this type for many years.

2.342 Additional steps comprise special shipping papers — a step usually performed by the supplier — customs clearance by proper authorities, and payment through an external account or through a letter of credit.

How are overseas purchases dealt with in your RDI? Do you consider the procedures to be very satisfactory? If not, what could be done to improve the situation?

Case #2.4:
For overseas purchases, the large RDI referred to in the preceding case, proceeds with the following steps:
(1) Preparation of Order (imports).
(2) Preparation of Draft (Bank),
2.343(a) In certain cases, customs clearing can take quite a long time. There are instances where delays are caused by RDI personnel, while others are due to suppliers or to government officials. Obviously, RDI personnel have more influence in the first two cases than in the third one.

2.343(b) Normally, proper documentation, adequate follow-up, and good relations with customs authorities should greatly contribute to control abnormal delays due to customs.

2.344(a) When the volume warrants it, it is suggested that at least one purchasing agent becomes a specialist in customs clearing. There are a lot of technical aspects in that area, including import regulations, clearing documentation, and forwarding. None can be neglected.

2.344(b) Accordingly, it is appropriate to have a detailed description of all those steps in the manual of procurement procedures. This approach will reduce the risk that an RDI become overly dependent on one or two individuals in that respect.

2.345(a) An interesting alternative is to purchase the services of customs brokers, when such companies exist locally. This type of company is specialized in customs clearing and its personnel will normally make any possible effort to accelerate the clearing process. In many instances, it is cheaper and faster to use this type of services than an in-house expert.

2.345(b) A broker is less likely to forget materials or equipment in a warehouse for a long period, than RDI personnel with unclear responsibilities. For instance, fieldwork revealed instances of equipment staying at customs warehouses of the importing country for long periods. Once again, follow-up is critical.

2.346(a) Knowledgeable in-house or outside personnel can indicate when an RDI is exempt from paying customs duties and/or sales tax. They also can do all the necessary procedures in order to get such a clearance. It is a matter of knowing regulations and this is not an easy task.
considering all exceptions and frequent modifications to this area.

2.346(b) Potential savings in this area should not be underestimated, as they could represent at least 1 or 2% of the total budget of an RDI importing many goods, and not having paid enough attention to this aspect so far. An in-house or official list of exempt items is a good starting point for saving in this type of situation.

2.347(a) Customs clearing is RDI's responsibility when the RDI owns goods from their origin point or from any other point outside the country. The point where the RDI becomes the owner of the goods is called “Freight on Board” (FOB) point.

2.347(b) When this FOB point is the RDI site, then all responsibilities and problems are the shippers. Therefore, when possible, it could be interesting for RDIs to examine FOB points for problematic situations. This approach could be particularly useful for RDIs with no expert in imports, including in customs clearing.

2.347(c) In fact, transportation services can usually be acquired quite easily. What is more difficult is the follow-up on the services provided and the optimization (best combination) of delivery time and cost.

2.347(d) Damages to goods should be collected from the transportation company. Although it appears difficult to measure the quality of transportation services, damages and punctuality are two criteria which can be used for this purpose.

2.348(a) Transactions in foreign currencies also constitute an acute problem for two reasons: difficulty to obtain funds, and problems in understanding this type of transaction. The first type of problem can be solved in part by improving the efficiency of operations of RDIs. Other economic and political considerations are beyond the scope of this Manual.
2.348(b) The second type of problem has more to do with proper training of those involved in this type of transaction. While it is obvious that local purchases have the advantage of avoiding foreign exchange problems, a number of goods have to be imported from overseas.

2.348(c) Whenever possible, RDIs dealing quite often with foreign countries should have an external account, a situation which enables an RDI to pay the supplier directly. Procedures for payment in foreign exchange in those instances where the importer has no external account need to be more definitive and clearly laid out for all those who are likely to do this job. This is another example illustrating that written procedures cannot replace adequate training, but should rather support it.

2.349 Overseas purchases represent an excellent opportunity for RDIs to collaborate and learn from each other. When RDI personnel is confronted with a specific problem, it is likely that personnel in another RDI has faced a similar situation, and would be happy to discuss their approach in solving it.

2.351 Accelerating Time for Procedures: When a purchasing department is staffed with competent personnel who are sufficient in number, it would be easy and fast to fill out purchase orders without proper attention to other procurement aspects. However, as mentioned before, this is not the only purpose of a purchasing department. For instance, the proper selection of suppliers requires time, which is often justified on the basis of attaining better objectives such as reduced delays and improved quality.

2.352 Putting unnecessary pressures on the purchasing department can only reduce their efficiency and even their effectiveness, a result which is detrimental to the entire RDI. In many instances, it should be recognized that users could have anticipated their needs.

2.353 It is usually possible to process a transaction faster, when circumstances justify it. In fact, it is simply a matter of giving priority to this transaction over the others. It might even be

If you have not already done so, think about personnel in other RDIs as colleagues whose overall objective is the same as yours.

Do users often put much pressure on purchasing agents in your RDI? How could the situation be improved?

Simple, isn’t it?
possible to convey the message of the importance of this transaction to the supplier, to the transporter, and sometimes even to customs authorities. It is obvious that most individual transactions can be accelerated by using such a procedure, although it is impossible to do so for many transactions at the same time.

Why is it the case?

2.354 An interesting option for frequent purchases consists in pre-authorizing the purchase of certain items up to a specified quantity. The issuance of standing purchase orders for certain supplies makes it possible for a storekeeper to know a supplier and obtain immediate delivery.

2.361 Budgets: Procedures like the one just mentioned are made possible by allocating the overall RDI budget among all departments. Then each department, in collaboration with the purchasing department, buys goods and services required to operate efficiently.

What are those limits in the case of your RDI? Are these limits indicative of an approach based mostly on centralization or decentralization?

2.362 Procedures usually specify accepted ways of acquisition. They also provide details about the hierarchical level of the person who must authorize purchases. For instance, purchases below $500 can be authorized by the head of the user department, those between $500 and $9,999 have to bear the signature of the Procurement Officer, while those of $10,000 and over should be authorized by the RDI top official.

Why would budgets be accepted if there are insufficient funds to purchase all items required?

2.363 There is sometimes a confusion in the minds of users, regarding funds and budgets. A positive balance does not imply that funds are available for purchases. So, there is a need to promote a greater awareness on the part of the researchers that budgetary provisions and availability of cash are two entirely different issues.

2.364 Users should be made aware on a regular basis about funds available for RDI operations. However, there is a danger when funds get scarce too often: users might want to purchase items too much ahead of time, just in case no more funds are available at the time they would normally buy these items.
2.365 Users should also know budget balances in order to plan purchases. When microcomputers or terminals are available, information could be available within a few seconds. This is not often the case. Accordingly, it is the responsibility of the purchasing or of the information system department to provide these figures regularly to users. This step shows good collaboration, and reduces the number of requisitions which have to be returned to users because they do not have sufficient amounts in their budgets.

2.371 **Improving Procedures:** Computers can greatly improve order processing time and information availability. However, they do not replace sound judgement, nor do they modify substantially good procedures already in place.

2.372 The best approach is to challenge existing procedures about once a year, in order to try to improve them. All personnel could also make suggestions about modifications that they believe useful.

2.373 More and better training increases the level of responsibility that individuals can assume, and could increase the number of suggestions. It should never be forgotten that persons directly involved in an operation are usually the ones who know it better.

2.38 Overall, procedures are likely adequate if there is a positive answer to each of the following questions:

1. Are users satisfied with procedures?
2. Do users follow procedures?
3. Is internal control considered satisfactory?
4. Are procedures reasonable considering the size and the nature of the operations of the RDI?
5. Does procurement provide the benefits expected by top RDI officials?

2.39 Sections 2.4 to 2.6 deal successively with three major considerations in terms of procurement: selection of sources of supply, price determination, and quality.
2.4.11 Selecting Sources of Supply: Supplier selection constitutes an important activity of a purchasing department. While it is easy to purchase goods or services always from the same suppliers, this is not necessarily the best approach from the entire ROI standpoint.

2.4.12 As mentioned in section 2.1, suppliers provide RDIs with what they need, when and where they need it, and in the quality and quantity desired. The selection of good sources of supply can contribute substantially to the success of ROI operations. Unfortunately, this reality becomes obvious when errors are made in the selection process.

2.4.13 Reliability of lead times and inventories on hand are two important criteria in the selection of suppliers. These criteria are particularly critical when an ROI does not keep high quantities of inventory on hand, and when their stock system is based on suppliers reliability. Details about these aspects are provided in Chapter IV.

2.4.14 Efforts in terms of procedures and organization can be much less useful if suppliers do not live up to ROI expectations. In fact, suppliers fulfill users needs. However, what is difficult is not necessarily to find any supplier, but rather to select the best one available in the circumstances. This is why this task can usually not be given to a stores clerk for instance.

2.4.15 At any rate, research scientists, stores staff, or any user could help purchasing agents in locating interesting suppliers. This collaboration could benefit to all those concerned. It is important particularly when it is difficult to determine suppliers for items which are difficult to get, or when existing suppliers are unsatisfactory.

2.4.16 It requires continuous efforts to determine those suppliers more likely to provide an ROI with the "best buy" it can get. Available time often limits this type of effort. Figure 2.4 illustrates the basic steps to go through in the supplier selection process.

Why is it more obvious when errors are made?

What are the 2 key criteria in the selection of a supplier for an important material used in your ROI?

(1) ________________

(2) ________________

Who knows it when an existing supplier is unsatisfactory?

How would you define the "best buy"?
Figure 2.4. Basic Steps in the Supplier Selection Process

PURCHASE REQUISITION

- Is this a regular item?
  - Yes
  - Is there an annual contract for it?
    - Yes
    - Negotiate and select supplier
    - No
    - Was last supplier satisfactory?
      - Yes
      - Invite quotations
    - No
      - Place order for the item
  - No
    - Evaluate and monitor performance

- Is it time to check the market?
  - Yes
  - Make short list of possible suppliers
  - No

Source: Baily, Peter J.
2.421(a) What type of supplier is it preferable to select? Many combinations exist along the following characteristics:

- Local or overseas?
- Small or large?
- New or existing one?
- One or many?

2.421(b) Each choice has its advantages and disadvantages. These will be looked at briefly in the coming paragraphs. At the outset, it should be emphasized that there are often important differences among groups, a reality which makes it difficult to generalize excessively the following observations.

2.422 Local suppliers can usually provide a faster service and be more enthusiastic about having additional business than overseas suppliers. However, this latter group can also provide a good service if service is what they emphasize.

2.423 Similar issues come up when there is a choice between a small and a large supplier. Small suppliers should establish themselves. Therefore, they might be ready to make interesting deals with RDIs, which often appear as prestigious clients. On the other hand, large suppliers have larger inventories and, eventually, more knowledgeable staff.

2.424(a) An existing source of supply might be satisfactory, but it does not mean that a better one cannot be found. However, changing suppliers can be a costly process in the long run if the new supplier does not live up to expectations. The present procurement philosophy suggests to keep an existing supplier when there are minor differences with others.

2.424(b) It could be particularly tempting for RDIs to change suppliers when a new one offers a better price than the existing one. Once again, price represents only one variable to look at when it is time to select a supplier.

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If you think that such comments do not provide you with THE right answer, you are right: there is not necessarily a right answer, even when circumstances are known. It is indeed possible to get a more appropriate answer only if both options are tried simultaneously.

It is often difficult for organizations subject to public accountability to justify the selection of a supplier other than the one offering the lowest price. Is your RDI faced with a similar situation?
2.425(a) There is a delicate equilibrium to strike between one and many suppliers. Previously, procurement philosophy suggested to have more than one supplier in order to obtain the best possible deals. Since the last few years, this philosophy has changed because it is now recognized that an excellent supplier is much more than the one who offers the best price. For instance, lead times and quality level can be more important than price, as long as price stays within reasonable limits.

2.425(b) Purchasing from more than one supplier reduces the likelihood of volume rebates and, sometimes, it does not make it possible to obtain quantity discounts. In some cases, these savings could have been significant.

2.425(c) Standardization of purchases reduces the number of different spare parts and the quantity thereof to be held in stock. If more than one supplier provides a specific type of goods to an RDI, proper attention should be paid to this aspect. Standardization is particularly important for RDIs with much equipment or with important inventories, whether in value or in number.

2.431 Make-or-buy: Selecting suppliers implies that a choice has already been made not to make the goods or to perform the services required. This choice is obvious when it comes to most of the chemicals or sophisticated equipment. However, it is not, when the decision is related to activities which could also be performed competently within the RDI.

2.432 In-house personnel is more aware of the RDI activities than outside contractors. But they represent a fixed expense when they are not productive. Furthermore, there is a tendency to increase the size of an RDI by adding operations which are not part of the mainstream of activities of the RDI.

2.433 Therefore, it is usually recommended that organizations faced with a make-or-buy situation, have as much of their operations as possible performed outside, as opposed to in-house.
2.434 An interesting compromise exists: rather than to consider the choice as being a complete make — or perform — inside, or a complete buy, an examination of all combinations could reveal interesting options (Leenders and Nollet).

2.435 Maintenance activities constitute a good example of such a combination of in-house and outside acquisition of a service. The purchase of maintenance activities will be examined in further detail in Chapters III and VI.

2.436 The selection of a supplier is often more difficult for services than for physical goods. Services are intangible. Often, they should be evaluated based on suppliers reputation and performance in similar circumstances. This explains why the determination of the fairness of a price is more difficult in the case of services than in the case of goods.

2.51 Price Determination by Suppliers: Suppliers must receive a fair price, if they want to stay in business. Considering that their role is essential for RDIs, it is important to pay them a fair—but not excessive—price. This approach is essential to maintain good relationships with them.

2.52 Purchasing agents should be aware of the different methods used by suppliers to establish their prices. If they can do it, then they will be able to determine if the prices charged by the RDI’s suppliers are justified. Otherwise, purchasing agents will have to rely on comparisons among suppliers, on previous prices paid, and on the reasonableness of those prices as compared with the amounts that an RDI is ready to pay.

2.531 Suppliers usually determine their prices on at least one of the following bases:

- Competition;
- Law of supply and demand;
- Costs incurred plus a profit margin.

Graphically, this can be represented as in Figure 2.5.

Can you provide an appropriate example—other than maintenance—and specific to your RDI?

How do you evaluate the fairness of a price in the case of services?

Aren’t these methods sufficient? No! Not always. Why not?
Figure 2.5. Determinants of Price

COST

DEMAND

COMPETITION

2.532 The first basis is used mostly for items which can be quite easily obtained from many suppliers. Tyres, most scientific standard glassware and equipment, and many chemicals fall into the category of prices based on competition.

2.533 Supply and demand play a direct role in the determination of the price for commodities such as grain and metals. Some types of research performed by RDIS require the acquisition of commodities. One of the major challenges in commodities buying is price forecasting.

2.534 Suppliers' costs can be used as a fair basis for price when a user's need can only be satisfied with a customized product. In this type of situation, a purchasing agent will determine the reasonableness of the estimated costs and profit margin on the project. Construction of a new special-purpose building and special equipment are two examples of appropriate situations where this approach to price determination is used.

2.541 Purchase Price Determination: There are four major ways used by a purchasing agent to determine the price to be paid to a supplier:

- Usual purchase order procedure;
- Special contract agreement;
- Tendering process;
- Negotiation.

2.542 As illustrated in Figure 2.6, there are relationships between these four methods and the three methods used by suppliers to determine their prices.

2.543 The usual purchase order procedure is recommended when items are purchased at the
Figure 2.6. Relationship Between Methods of Price Determination by Suppliers and Buyers

<table>
<thead>
<tr>
<th>Competition</th>
<th>Supply/Demand</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase Order</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Special Contract</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Tendering Process</td>
<td>x</td>
<td>x and *</td>
</tr>
<tr>
<td>Negotiation</td>
<td>x</td>
<td>x and *</td>
</tr>
</tbody>
</table>

X = Frequent way to proceed
* = Steps normally preceding a special contract

regular price list, for instance when it is impossible to get discounts other than the usual ones or when purchases are made in small quantities.

2.544(a) A special contract agreement is usually made when the price is based on a suppliers costs, due to the special nature of a project. This procedure and the preceding one could also come as a result of a tendering process or of a negotiation.

2.544(b) Contracts are made in writing in case any disagreements arise at any stage of the transaction. This is why careful attention should be paid to avoid ambiguities and mistakes.

2.544(c) However, contracts do not prevent breach of contracts on the part of the supplier, particularly if the latter feels that the terms of the contract — in final consideration — are not enough to his advantage. Although legal procedures could then be taken against the supplier, this approach does not solve the immediate problem of obtaining the required goods. This is why it is important that all transactions be advantageous for both parties.
2.545(a) The third method is based on bids received from suppliers invited to quote a price. In the case of public bidding (open to all), all suppliers are allowed to bid. The lowest bidder usually gets the contract.

2.545(b) This approach is used to provide a fair chance to all suppliers to obtain some business from an RDI. It is often mandatory for most RDIs to proceed in this manner, when a contract exceeds a certain amount. However, it should be noted that this process is costly due to the detailed description required in bids and bids analysis.

2.545(c) Many RDI managers might be interested to know that, in some government agencies as well as in the private sector, there is a tendency to get away from this costly form of price agreement. The reason is not only the cost, but also the exaggerated importance given to the price mentioned in the bid; other factors are important as well.

2.546(a) A negotiation can be used whenever there is an aspect of a suppliers proposal which it is preferable to modify. A negotiation is not a fight at the end of which there is necessarily a loser. It is rather a discussion intended to settle some aspects on which an agreement has not yet been reached.

2.546(b) A negotiation can be costly; it should be used for major aspects only, unless minor ones can be settled rapidly by using this approach. It is particularly recommended when there is only one supplier, when prices seem excessive, or when the contract being discussed covers a sufficiently long period of time.

2.55 This discussion on price determination was intended to provide RDI managers with important background information on the different approaches used by suppliers and by buyers. Both sides aim at reaching an agreement, because it is to the benefit of both parties involved.

2.61 Quality and Inspection: Once a source of supply has been determined and a price agreed upon, the selected supplier sends the goods or performs the services required as per the agree-
ment. In the case of goods, these are inspected upon delivery, to ensure that the quantity and quality agreed upon have been adhered to.

2.62 The best assurance of the quality of goods is the supplier himself. In certain cases, it might not even be justified to inspect materials received from some of the suppliers. For instance, this could be a gradual process whereby inspection would be less and less strict as a supplier proves to be very reliable. It should be noted that few suppliers deserve such high confidence, particularly if the materials delivered are critical to a research process.

2.631 There are a variety of ways to specify the level of quality desired. Some of these are:

- Chemical or physical specifications;
- Performance specifications;
- Blueprints and drawings;
- Accepted norms;
- Market standards;
- Trademarks,
- Providing a sample.

2.632 In most instances, there is an accepted way to specify quality. For instance, sulphuric acid is usually ordered by specifying not only the name of the product, but also a few other important chemical characteristics such as clarity.

2.64 Inspection of items received is important, because it is often at this time that an RDI becomes owner of this merchandise. It is necessary to pay for what is invoiced by a supplier, unless inspection reveals that the quantity, the quality, or the nature of the items received does not correspond to what has been ordered.

2.651 Receiving and inspection reports provide evidence of the arrival and inspection of goods. Fieldwork revealed that documentation procedures relating to receiving of equipment delivered to the RDI were generally unsatisfactory. Inspection reports and receiving reports were not always prepared and, therefore, it was not easy to determine whether the goods ordered conformed
with the specifications or if the equipment was in good working order.

2.652 A Manual of procurement procedures should also include information about the responsibilities for receiving and inspecting materials received, and for documenting each transaction properly. In fact, receiving reports should be made by the receiver upon reception, while inspection reports should be made as soon as possible. In many cases, it is done by the same person when the items received do not require a special expertise in order to evaluate summarily their quality.

2.653 It is often impossible to determine if the items received are perfect on all grounds. However, an inspection might reveal the most apparent problems, provides evidence in case of discussions with a supplier, makes any follow-up easier, and constitutes useful information about a supplier's performance.

2.654(a) The issue of centralization of stores will be dealt with in other chapters. At this stage, let us note that centralization corresponds to a clearer responsibility and to better control than decentralized stores. However, decentralization is justified when there is too much volume, when the nature of the items received allow for specialization, or when RDI units — even on the same land — are quite apart one from another.

2.654(b) It should be kept in mind that physical and documentary controls over items received should be a major preoccupation of any RDI where managers want to improve materials management.

2.661 Usually, centralization allows for better trained personnel. This characteristic is very useful when it comes to sampling plans regarding inspection to be performed on incoming items.

2.662 Definition: A sampling plan is composed of two elements, namely the sample size and the limit number of defects tolerated, in the sample in order to accept the entire lot based on the sample inspected.

For which materials used in your RDI is it possible to determine upon inspection whether or not the quality level is appropriate? For which isn't it possible?

Are sampling plans used for inspecting incoming goods in your RDI? Are they based on statistics or not?
2.663 Sampling plans are a normal part of inspection procedures. They should normally be based on statistics and can be relied upon when they are used properly. They do not guarantee that the incoming lot has the same characteristics as the sample, but rather that it is likely the case, with a known probability.

2.664 This statistical tool is particularly useful for large incoming lots, because it is then necessary to inspect only a small fraction of the lot in order to make a decision. In all cases of sampling, it is important to ensure that every item has a similar probability to be inspected.

2.665 There are tables which can be used for easier determination of the appropriate sampling plan. These tables are called ABCSTD 105D, but are not as accurate as statistical plans determined specifically for each incoming lot. However, they are more widely used, because they are easy to understand by personnel unfamiliar with statistics.

2.666 It is suggested to readers interested on the topic, to get all details on sampling plans in any quality control or operations management textbook.

2.71 Conclusion: The purpose of this chapter was to provide RDI managers and staff with information on procurement aspects which are of particular interest to them. The topics covered included the objectives of procurement, organizational aspects of a purchasing department, and procurement procedures. The last three sections examined the selection of sources of supply, price determination, and quality and inspection.

2.72 These procurement aspects provide a basis for coming chapters, but particularly for the next two chapters, Chapters III and IV. It is indeed equipment and materials which constitute most of the purchases made in an RDI.
PROCEDURES MANUAL OUTLINE—PURCHASING

(A) GENERAL

The objective of procurement procedures is to provide an organization with items and services needed at the right place, time, price, quality and quantity. It is important that the following outline procedures be followed in order to obtain the required items and services.

STEP I: The user and/or the store stock control section will initiate the purchase activities using purchase requisition documents. The purchasing department identifies and approves the type of purchase required i.e.:
(a) Straight purchase by petty cash or imprest fund.
(b) By collecting quotations from suppliers.
(c) By invitation of tenders — through radio or newspapers.

STEP II: (a) Search for supplier.
(b) Select supplier by price, past performance and good reputation.
(c) Consulting user department for quality.

STEP III: (a) Verification of availability of funds.
(b) Place orders using L.P.O. or contract documents.
(c) Petty cash purchase.

STEP IV: At this point a follow-up is made to check and confirm that documents are through and delivery is under way.

STEP V: (a) Inspection of goods received through delivery notes.
(b) Verification and documentation of goods received.

STEP VI: Delivery of goods to users department with accompanying issue notes or to stores for storage.

The following paragraphs are instructions developing some of the steps above.

SPECIFIC INSTRUCTIONS

I — General Rule

Commodities and services required in the course of the RDI's activities shall be obtained as economically as possible. However, the RDI's activities shall not be handicapped for the sole reason of cost saving, e.g. by purchasing products of inferior quality, products in respect of which inadequate service facilities are available or products subject to an unacceptable delivery period.
II — Purchases

2.1 Orders

2.1.1 Except for petty cash purchases (see 2.4), all commodities and services required by the RDI shall be obtained by official written order.

2.1.2 Orders shall be placed by the Buyer only. An order shall be placed upon submission to the Buyer of a Purchase Requisition for supplies and services duly authorized by an Officer with appropriate financial signing authority.

2.2 Quotations

2.2.1 Quotations shall be obtained before an order is placed with the supplier of any commodity or service. Such quotations shall be in writing in the case of capital equipment or goods imported on behalf of the RDI, and for which the value of which exceeds (as may be determined).

2.2.2 As a rule, more than one quotation shall be obtained in respect of each order. According to the discretion of the Buyer, it may not be necessary in cases of availability of specific commodities or services, urgent deliveries, repeat orders, etc.

2.2.3 Where more than one quotation is obtained, the lowest shall be accepted unless reasons for the acceptance of an alternative quotation can be furnished to the Buyer's satisfaction.

2.3 Urgent Purchases

In cases of exceptional urgency, the Buyer may reserve an order and permit an Officer to obtain commodities or services from specific suppliers on the basis of such reserved order provided that particulars of the commodities or services obtained together with a duly authorized Purchase Requisition for Supplies and Services shall be submitted to the Buyer within seven days from the reservation of such order.

2.4 Petty Cash Purchases

Commodities or services with a net value not exceeding (as may be fixed) may be obtained on behalf of the RDI by any Officer from his private funds, provided that repayment of such expenditure to the Officer shall be subject to the submission of a duly authorized petty cash voucher and an invoice or cash slip as proof of expenditure.

2.5 Purchases Abroad or Overseas

Goods or services not available locally may be obtained abroad through the media of agents or in the manner advantageous to the RDI.
2.6 Standing Orders

Orders extending over a financial year may, where necessary, be placed for the supply of commodities or services on a repetitive basis e.g. the purchase of paper supplies, call out technicians to carry out maintenance of capital equipment, etc., provided that payments resulting from such orders shall only be made on the basis of invoices from the relevant suppliers which have been certified for payment by an Officer with appropriate signing authority for the division concerned.

III — Recording and Payment on the Basis of Orders

3.1 A continuous and complete record shall be kept of all purchase and service transactions in respect of which orders were issued.

3.2 Payment for commodities and services for which orders were issued shall be subject to:

(a) Submission by the supplier of an invoice or statement showing particulars, and the cost of the commodity or service concerned; and

(b) Certification of receipt of commodities in an undamaged or serviceable condition or satisfactory rendering of service.

3.3 Payment for commodities and services shall take place after delivery provided that advance payments may be made in regard to fixed service contracts for capital equipment. Further, advance payments may be made with the approval of the Chief Executive, to obtain goods or services or to secure the most favourable buying conditions for the RDI.

IV — Transactions with Interested Parties

No order for any commodity or service to be rendered outside one's normal official duty shall be placed with any organization in which one has a direct financial interest, except with the specific approval of the governing authority.
PROCUREMENT: Selected readings for more study


MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D INSTITUTE FACILITIES AND MATERIALS MANAGEMENT

CHAPTER III

EQUIPMENT
EQUIPMENT

Training Objectives

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

1. See equipment in the context of its logical steps.
2. Explain the advantages of standardization.
3. Evaluate equipment following a life cycle concept approach.
4. Relate equipment specific procurement procedures with procedures discussed in Chapter II.
5. Know how to control equipment.
6. Determine the importance of proper personnel training on the useful life of equipment.
7. Relate maintenance concepts for buildings and for equipment.
8. Explain how to reach the optimal maintenance zone.
9. Describe the impact of spare parts on uptime.
10. Explain the three most frequent types of failure distribution.
11. Discuss pros and cons of maintenance performed by RDI personnel as opposed to outside contractors.
13. Understand the characteristics of equipment disposal.
EQUIPMENT

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This material should be covered in two sessions. It can be expected that the second session could be a little longer than the first one.
CHAPTER III

EQUIPMENT

3.111 Introduction and General Considerations: Equipment facilitates operations within organizations, by increasing the speed, the accuracy, or even the feasibility with which they can be carried out. It is often identified with technological progress. It contributes substantially to the achievement of national development goals, or at least it is believed that it does so, considering the substantial amounts devoted to the acquisition of equipment.

3.112 Definition: Equipment consists of all fixed assets other than land and buildings. Thus, it includes laboratory equipment, automotive equipment, furniture, computers, and all other items which have a useful life of at least one year.

3.113 This chapter revolves around the logical steps in the useful life and disposal of equipment. This sequence is presented in Figure 3.1. It begins with definition of a need, which precedes the acquisition process. Before a piece of equipment is even used, it is preferable to identify storage space if required, and to decide about safety and control measures additional to those already in place. Then comes its use, with the important support of maintenance. During its useful life, equipment

What types of equipment are used in your RDI?

It is useful to think about this sequence particularly at the time of acquisition to help in the planning of subsequent steps?
will be appraised. Finally, disposal follows. An outline of procedures for equipment is provided at the end of this chapter in order to allow for an overview of the important aspects to consider.

Figure 3.1. Steps in the Useful Life and Disposal of Equipment

3.114 People, land, buildings, equipment, energy and money are resources used to make desired activities possible. They do not constitute the basic raison d'etre per se of an RDI. Once again, it should be emphasized that RDIs exist to contribute to the achievement of national goals. Consequently, it is in this perspective that equipment should be managed.

3.121 Definition: Technology is a set of equipment, know-how and procedures making possible the mastering of the way to achieve specific desired results. All RDIs have equipment. In fact, most have some very expensive equipment in order to perform the sophisticated research and development work they do.

3.122 Even sophisticated equipment is not by itself a technology. Because equipment is only part of a technology, acquiring only equipment does not necessarily solve the problems the acquisition was supposed to solve. On the other hand, equipment being one of the three components of a technology, it is necessary to make proper decisions about it if a technology is to be fully useful.
3.123 Managers should recognize whether the intended equipment is part of a technology different from the ones presently used in their RDI. If it is the case, more acquisition, proper use and maintenance problems are to be expected than otherwise. For instance, equipment considered might be more sophisticated and complex than what is currently used. This overall approach makes it possible to anticipate important problems which are often difficult to perceive beforehand.

3.131 **Definition of a Need**: It is not always easy to define exactly what need a piece of equipment will satisfy. The main reason stems from the difficulty to segregate the need from a specific type or make which is believed to satisfy it. Unless all reasonable options have been examined, there is no sufficient reason to make too quickly such an expensive purchase. There are instances where the purchase could have been planned a few years ago, but it was not. That situation leads to undue pressures on the purchasing department.

3.132 A pressing need usually does not allow for waiting to order equipment when economic activity is slow. In such times, suppliers are more anxious to make sales and are often ready to make price concessions and to offer improved service.

3.133 When the need is so pressing that a rush order has to be placed, transportation costs in particular might be more expensive. Furthermore, supplier lead time for delivery is not necessarily shorter.

3.134 Users should also plan the intended use of the equipment over its useful life. It is not sufficient to know the present need, because the quality characteristics which are important might be quite different. For example, a department might request a new four-wheel drive vehicle to replace the 12-year old one in use, although it is intended to use the vehicle mostly in cities and on short distances. If it is going to be used for geological survey trips, then the four-wheel drive could even be equipped with recently-developed heavy duty accessories.
3.135 Equipment needs maintenance, enough space to be used properly and, sometimes, storage space also. All these considerations must be kept in mind right from the beginning.

3.136 Most equipment used in RDIs is purchased based on the necessity to replace old equipment, or because of its expected usefulness for the intended purpose, e.g. improved accuracy. There are other needs or reasons which should be taken into consideration; for example, economical factors could justify the purchase of a new piece of equipment, although the previous purchase was done only a few years ago. Another reason could be that the purchase of some equipment makes necessary the purchase of compatible equipment. Safety and health considerations could also prevail.

3.141 Financial Considerations: Acquisition of specific equipment is made at the expense of other equipment, hiring more personnel, etc. This is an important observation to remember when purchasing expensive equipment, due to the large quantity of resources such equipment uses up.

3.142 Whenever possible, it is preferable to plan acquisitions more than one year ahead, which makes possible the development of an equipment budget. This period allows time for top RDI managers to make clear choices in terms of what equipment will be purchased, and to discuss with funders the justification for the purchases. The fact that much of the expensive equipment is purchased overseas and necessitates foreign currencies provides another reason to do such planning.

3.143 Knowing replacement costs and the useful life of all major pieces of equipment allows for more accurate budgets than when these costs are only estimated. Because RDIs are not profit-oriented organizations, RDI managers do not have to be preoccupied mostly with return on investment (ROI) considerations. However, this is not to imply that ROI should not be considered for certain types of equipment such as word processing machines.
3.144 When funds are insufficient, proper consideration should be given to rent equipment. This option implies that a rental expense will be paid monthly, which might be more acceptable to some governments, than a 20% or a 25% up-front payment.

3.145 Another interesting option is to purchase used equipment. Doing so is less expensive and meets user requirements. Although it is possible (certainly not sure) that maintenance costs and the probability of failure will be higher, it could still be worth it, particularly if important savings are realised at the time of acquisition and if a proper preventive maintenance programme exists. The market for used equipment differs somewhat from the one for new equipment, and sometimes requires special expertise in that area.

3.146 It appears that equipment received free constitutes a better deal than when it is purchased. This is obviously the case from a purely financial standpoint. However, there should be an immediate need for it. Also, maintenance costs could be high, and maintenance as such, difficult to perform. Furthermore, training may not be easily available.

3.151(a) Definition: Standardization refers to the systematic formulation and adoption of standards. This is usually accompanied by variety reduction, which is the reduction of the range of items used, stocked, bought or made by an RDI.

3.151(b) Whenever possible, it is preferable to purchase only one or a few different makes of equipment suitable for a specific purpose. There are many reasons for doing so. First, the dealings will be made with known suppliers about equipment known to be reliable. Service from this supplier will have been experienced previously. It is assumed that if it was unsatisfactory, an agreement can be reached before the decision is made to change suppliers.

3.152 Information should be sought about new equipment. The gathering process will likely be easier when it is not the first recent purchase from the supplier considered. Other users could provide

Why only "possible" rather than "sure"?

Why isn't it always possible to have standardized equipment?

Case #3.1:
An RDI specialized in medical research had problems regarding installation, use and maintenance.
valuable information about a type of equipment they already use.

3.153 Proper installation, use and maintenance are all necessary conditions to have efficient equipment. They are more likely to be met when there is standardization, simply because of previous experience of all those involved.

3.154(a) When standardization is applied, other likely benefits are:

- Wider choice of supplier and increased scope for negotiation;
- Larger orders and possibility of lower prices;
- Reduction to a simple routine of some parts of the work of design and purchase;
- Simplification of some orders, requisitions, and other documents.

3.154(b) Standardization makes it possible to invest less in spare parts. For instance, if a quantity of 5 spare parts is ordered for each of two different makes of equipment, a total of 10 is thus necessary. For two machines of the same make, a total of only 7 or 8 is often sufficient. These savings could be substantial, if we consider that the reasoning made previously could be generalized to most equipment and spare parts.

3.154(c) Quantity discounts can also represent interesting savings. Not only are these more likely when an RDI orders larger quantities, but the percentage of discount offered may also be higher. Sometimes, volume rebates are also available from suppliers, when a preset amount is purchased annually.

3.154(d) Finally, standardization allows for systems compatibility. Although this latter concept is mostly thought about for computers, it is applicable to all systems. Its importance will only increase, considering the large number of information systems which are now computerized.

3.155 While the policy of standardization is really meaningful, the purchases of many pieces of equipment usually depends on political and economic ties between the buying and supplying

Some equipment took a long time to be installed, because nobody knew how to install it. Proper use was mostly based on trial and error, because most operating manuals were in French. As for maintenance, nobody knew how to do it.

Is it possible to demonstrate this reality by using statistics? Try to explain logically why these numbers make sense.

Considering all the advantages stemming from standardization, one person interviewed during fieldwork suggested that standardization should be generalized countrywide. What is your opinion?
countries; however, both RDIs and government should encourage standardization where possible.

3.161 **Definition:** Reliability refers to the duration of proper functioning (of a piece of equipment in this case). Users acquire equipment expecting that it will work most of the time. It is only when it is usable and used, that it is productive. Durability is the time an equipment produces reliable results under adverse conditions.

3.162 Reliability is particularly important when properly-trained maintenance people are scarce, downtime is costly, or spare parts are expensive and take long to arrive from suppliers. In fact, the more expensive the spare parts, the less likely they will be on hand at the RDI. Consideration should then be given to acquire nearly "maintenance-free" equipment. Initially, the investment will appear to be high, but the additional quality paid for should be compensated for in the subsequent years. Heavy duty equipment could also represent a sound investment.

3.163 Spare parts are often much more expensive than equivalent parts they are replacing. In fact, most equipment would cost at least twice its official price if it would be paid based on the price of spare parts only. For spare parts, there are also major differences among suppliers.

3.171 **Life Cycle Concept Approach:** The cost of equipment represents only one of the economical factors to take into consideration at the time of purchase. Installation, maintenance, and operating costs are also to be included in the decision. Other quantitative factors such as expected useful life, resale value and cost for major overhauls cannot be ignored either. Qualitative factors such as ease of operation, newness of technology and after-sale service (including availability of spare parts) also fall into the same category.

3.172 Quantitative and qualitative factors do not necessarily rank options in the same sequence. This is why the final choice of equipment represents a particular challenge. It is interesting to note that the overall final cost of equipment is never known accurately, making it impossible to
check the correctness of the initial choice in quantitative terms. However, available figures provide a good idea about it. Exercise 3.1 allows you to test your understanding of the basics of this approach.

Exercise 3.1: Life cycle concept approach

[Instructor(s): This exercise could be difficult for those without a proper financial training. Try to assess the level of each participant in order to put one more knowledgeable participant with one or two without much of a financial training.]

Situation:

The government of a Southern African country has assigned the following key objective to an industrial RDI: to help any small local company in choosing an appropriate technology.

One small company has requested RDI’s assistance in order to evaluate two weaving machines. Data gathered by RDI staff is as follows:

<table>
<thead>
<tr>
<th>Machine</th>
<th>Machine Y</th>
<th>Machine Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition cost</td>
<td>$10,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>Installation cost</td>
<td>$1,000</td>
<td>$300</td>
</tr>
<tr>
<td>Annual maintenance cost</td>
<td>$1,000</td>
<td>$200</td>
</tr>
<tr>
<td>Expected useful life</td>
<td>10 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Annual output value</td>
<td>$12,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>Materials cost</td>
<td>$2,000</td>
<td>$1,500</td>
</tr>
</tbody>
</table>

All other quantitative differences are considered minor. Which weaving loom would you choose, not taking into consideration any inflation and taxes? (These would make the computations a little more difficult while providing no immediate benefit to the participant in terms of his understanding of the life cycle concept approach.)

Based on quantitative factors alone, which machine would you recommend to buy? Which other factors would make you change your recommendations?

Do NOT read on unless you want to compare your solution with ours.
Solution:

In terms of differential costs, machine Y has a net output value of $(12,000 - 2,000 = 10,000)$, compared to machine Z with a net output value of $(8,000 - 1,500 = 6,500)$. Each year, Y has a more favourable output by $3,500$, although it costs $800$ more in annual maintenance costs. Machine Y has a net annual advantage of $2,700$, resulting from the difference between $3,500$ and $800$.

However, it costs $11,000$, as compared with $4,300$ for machine Z. Therefore, it costs $6,700$ more to buy Y $(11,000 - 4,300)$. Based on the following computation,

$\frac{6,700}{2,700} = 2.48$ years,

it will take approximately $2.5$ years before the additional investment in machine Y is recovered. For its remaining useful life, it should provide annually $2,700$ net over what machine Z would bring in.

Therefore, machine Y should be chosen.

Other factors to be considered could include:

- Newness of each technology;
- Cost certainty;
- Experience of workers with each type of machine.

3.2.11 Characteristics of Procurement Procedures: While Chapter 2 covered most of procurement procedures characteristics, there are additional observations which were left to this point, because they were mostly applicable or had a special significance for equipment. Some of the aspects which have an incidence on procurement procedures are:

- Equipment value is higher than materials value;
- Lead time is longer;
- Decision-making is complex;
- Expected useful life is long;
- Need for centralized purchasing.

3.2.12 What is the role of a purchasing department in the definition of a need? Generally-speaking, it is to give support to the user department. As was seen in the previous section, some procurement procedures begin as soon as discussions about the acquisition of equipment are held. For instance, preliminary information is gathered from potential suppliers.
3.213 Technical considerations are defined by users. They are the ones who evaluate the extent to which potential suppliers contacted by purchasing can meet the technical requirements. Naturally, they are also the most appropriate persons to make most of the inspections at the time of receiving and at the time of installation. The personnel of a purchasing department does not only perform most of the paperwork activities related to equipment purchases but it also works out economics-related clauses such as who pays for training costs.

3.214 It is obvious that only a very good collaboration between both departments will provide satisfactory results. Once again, this collaboration shows up in total lead time required from the definition of the need till equipment is installed.

3.215 Fieldwork revealed that many users are not aware of such lead times, with the result that they hold the purchasing department responsible for all time in excess of what was originally estimated to be the lead time. In some of these instances, the need was not defined sufficiently ahead of the expected date of delivery or anticipated date of use of equipment.

3.216 Furthermore, the requisitioning department was not always informed by purchasing about delays in expected delivery dates. Delays were due to any or all of the following reasons: processing foreign payments through letters of credit, actual processing and filling of order, shipping clearing and getting clearances from the appropriate government authorities.

3.217 Many of the RDIs visited had procedures for acquiring equipment, but it was doubtful whether they were effectively followed by all parties concerned. This reality might have been caused in part by the three following characteristics of equipment acquisition: lower frequency, more paperwork and higher technical content than most of purchases for materials.

Is this a typical problem in your RDI? If so, what has been done so far to improve the situation?

Case #3.2:
One systematically - organized RDI had the following procedures:

(1) Departments state their requirements.
(2) Notification to the Supplies Officer for summary.
3.221 **Technical Characteristics:** It should not be taken for granted that technical characteristics are necessarily beyond the understanding of those responsible for acquiring such equipment in the purchasing department. There is a wide difference between the characteristics of a manual typewriter and those of any complex research equipment. In fact, scientific equipment directly related to research work usually involves more difficulties for purchasers than automotive or office equipment.

3.222 If one person of the purchasing department is specialized in the acquisition of scientific equipment, technical aspects will be dealt with more expertise than otherwise. Such a specialization is particularly appropriate for large RDIs and for those which are capital intensive. It is likely that scientists will be even more inclined to collaborate with one or a few specialized individuals, than with just anybody in the purchasing group.

3.223 Centralization of purchases allows for more standardization in equipment bought, with the interesting financial and control results mentioned in the previous section. It also allows for a standardization of procedures, with the result that peculiarities of procedures for equipment purchases will be properly dealt with.

3.311(a) **Reasons for Security:** Equipment is valuable and warrants adequate security measures. Basically, equipment has to be protected against:

- **Damage:** by training staff,
- **Theft:** by hiring guards and also, by marking equipment,
- **Uncertainties:** by insurance coverage.

3.311(b) It is obvious that most measures taken for land and buildings (Chapters V and VI) will also be useful for equipment. For instance, adequately guarded premises should reduce substantially the likelihood of equipment theft. This procedure is particularly useful when security guards work regularly in an RDI whether hired by the RDI or an outside agency, because they know the personnel working therein.
3.312 The extent of security measures is not only related to the replacement cost of equipment. It is also a function of the value and usefulness it has for intruders. A vehicle and a typewriter might be more interesting items to steal than a sophisticated electronic microscope.

3.313 The usefulness of each individual piece of equipment for the RDI is another factor to consider. For instance, a vehicle is more easy to replace than an imported custom-designed item. This aspect emphasizes the importance to adapt security measures to the requirements of the situation, as shown on Figure 3.2.

Figure 3.2. Key Factors in the Determination of the Extent of Security

Select a specific piece of equipment used in your RDI. Evaluate the following aspects (circle your answer):

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usefulness for intruders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usefulness for RDI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value and usefulness for intruders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on your answers, what should be the extent of security measures?

<table>
<thead>
<tr>
<th>Extent of security</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.314 Efforts made within an RDI to promote and explain security to personnel and to implement adequate security measures to protect equipment can do a lot in terms of actually protecting it. However, it is not always easy to have personnel apply all measures. For example, one of the most well understood but less applied (in relative terms) security measures is to lock vehicles not in use.
3.321 Security Measures: It is important to ensure that suitable facilities exist for the proper custody of equipment. Limited access facilities, regular and special locks, and possibility of fixing equipment to permanent structures are the most important measures which make facilities suitable.

3.322(a) Clear identification of all equipment constitutes one of the best deterrents for thieves because it is difficult to subsequently sell this type of item. The serial number is not a sufficient identification mark: it does not indeed identify who the owner is.

3.322(b) It is suggested to engrave RDI's name with a number. Each number should be different from the ones attributed to other pieces of equipment; each department could have its own sequential number series, or the same numerical sequence could be used for the entire RDI. However, equipment disposal by the RDI could be more difficult due to the engraved numbers.

3.322(c) All identification numbers should be noted in an equipment register, kept in a safe place, usually on the RDI premises. Furthermore, a list and description of all equipment should be kept away from the RDI premises, so that it could be provided, should a fire destroy the RDI facilities. Such a list could include the replacement value for which each piece of equipment is insured.

3.323 Finally, it should be noted that insurance coverage represents a protection in case an undesirable event takes place. However, it provides a compensation which may result in higher insurance premiums in the subsequent years. Insurance is a last resort element that is necessary, but which does not replace all other security measures which can and should be taken.

3.331 Equipment Control: Adequate protection for equipment constitutes only a portion of equipment control. Proper documentation, an equipment register and an equipment loan register help to provide such control. Proper accountability by having only one person responsible for a particular equipment also constitutes an
appropriate control. Each of these aspects will be covered in the subsequent paragraphs.

3.332 Clear documentation on the receiving and acceptance of equipment is necessary, before any posting goes to the equipment register. If the receiving department acknowledges receipt from the supplier, the user department should do the same with the receiving department. In short, appropriate control over the physical as opposed to documentation on equipment should begin right from the time it becomes the property of the RDI. An RDI may even own equipment — or goods — before they arrive at the RDI. Figure 3.3 shows all control phases.

Figure 3.3. Importance of Control Over Equipment and Spare Parts

3.333 It was observed during fieldwork that the state of records relating to equipment was generally poor and that many RDis did not even have an up-to-date register showing what equipment the RDI had and where it was located. In fact, diversity and expensiveness of equipment justify to have such records. This observation is particularly applicable to those institutes doing basic research.

3.334 Records represent a good way to keep control over equipment, even if this control is not as such a physical control. It is often believed that they are not necessary, particularly in small RDIs. This is a wrong belief, as should illustrate the discussion on the topic.
3.335(a) An equipment register should include whatever information is deemed to be important. The most frequent information contained therein is usually the following: acquisition date, supplier, serial number, identification number, cost, depreciation rate, undepreciated value, location, maintenance costs and frequency, repairs and overhauls.

3.335(b) RDIs with computer facilities and enough terminals, or with an interconnected network of micros, could share the same data bank which would include the information mentioned above. Another possibility is to update diskettes regularly, when stand-alone micros are used. However, it is not sure that every user will get or receive regularly an updated diskette.

3.335(c) An equipment register is useful only if it is regularly updated. This way, decisions will be taken faster than otherwise. If the register does not provide up-to-date information, users will distrust it, and also, poor decisions could be made due to poor or wrong information.

3.335(d) If one individual is responsible for the update of the register record, it is more likely that the job will get done. This person could be the same as the one responsible for land and buildings. An alternative is to divide up this responsibility between the finance department and the maintenance department, respectively, for financial and maintenance aspects. However, responsibility-sharing is not always as efficient.

3.335(e) A regular examination of equipment would allow a comparison with the equipment register and the identification of obsolete, unused, lost or stolen equipment. A period of one to two years appears appropriate.

3.336(a) An equipment loan register must be maintained when equipment is kept centrally and can be borrowed by various user departments. It would include such details as the date borrowed, date returned and information on any problems noted either during use or upon return. This is to ensure that the equipment is in working order before and after return and, if it is not, what action needs to be taken.

Try to justify the reason for each of these informations.

There are wide differences among RDIs at this level: some have computer systems, others don't. However, it is not computers which are most important for efficient RDI operations, it is RDI personnel.

Do you see the difference between an equipment register and an equipment loan register?
3.336(b) The authorized borrower signs the register at time of taking out, while the storekeeper signs it when the item is returned back. This register should be signed even when equipment is taken out for maintenance.

3.341 Pooled or allocated? Pooled equipment increases the probability (likelihood) that some specific type of equipment will be used. The reasoning is simple. If movable equipment that is not in use is returned to a common pool (the store), it is available for other users. Sharing equipment might make it possible to acquire a smaller number of machines than if machines were allocated to specific departments. This concept is demonstrated in Example 3.2.

Example 3.2: Pooled vs allocated equipment

Situation:

An RDI specialized in biological research has three teams. Each team needs additional microscopes. Due to very restricted funds availability, consideration is given to pooling additional microscopes. What would be the impact of this policy on the number of microscopes purchased, if the following intended usage would be a typical day?

<table>
<thead>
<tr>
<th>Team</th>
<th>Time of day</th>
<th>Number required</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8:00 - 11:00</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>9:30 - 12:00</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>8:00 - 9:30</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>12:30 - 14:00</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>15:00 - 16:00</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>14:00 - 16:00</td>
<td>3</td>
</tr>
</tbody>
</table>

Solution:

In the morning, 5 are required: 3 for team A, and 2 for team C. When C is finished, B requires 1 for the remaining part of the morning. In the afternoon, 4 are required: 3 for team C, and 1 for team B.

As can be seen, the number required is the highest number needed at any time during the day. In this case, it is 5.

Under an allocation system, A would require 3 microscopes, B, 1, and 3 would be necessary for C. In total, 7, as compared with 5 under the pool system.
3.342 When equipment is pooled, the layout of a building will greatly influence the extent to which the savings in acquisition and maintenance costs will more than cover the cost of time lost due to moving equipment back and forth from the store to users. Therefore, the choice of a store location is important.

3.343 Individuals take better care of equipment when it is allocated to their department than when it is pooled. However, they become sometimes reluctant to let others use “their” equipment, even when the others are from within their own department. If the head of a department decides to lend equipment to another department, it is recommended that the borrowing be done through a loan register system similar to the one described above.

Case #3.3: In an RDI with many vehicles, it was found out that these were not properly taken care of because a pool system was in effect. It has now been decided to allocate these vehicles to specific departments to enhance responsibility.

3.41 Storage Areas: Some concepts about storage areas are also mentioned in Chapters IV and VI. This approach allows to cover mostly ideas specific to the chapter under study. Therefore, it is suggested to the reader who is mostly interested in the topic of storage areas to read all three sections of the appropriate chapters.

3.42 Storage areas for equipment are required for one of the following reasons: pooling of equipment, inappropriate other control measures when it is not in use, insufficient work space, and low utilization rate. These reasons may or may not be valid. Only a proper analysis of the situation would make it possible to determine their validity.

3.43 All equipment deserves suitable storage areas. This idea is also applicable for automotive equipment, including farm equipment. Sometimes a shelter would suffice to increase equipment useful life. Once again, although space is costly, storage areas should also be seen as an opportunity to protect productive assets.

3.44 It is appropriate to re-evaluate regularly the equipment in storage areas. Equipment that should have been disposed of may occupy critical storage space or space that could be used for operating other equipment. Storage areas are not appropriate for storing permanently obsolete or unrepairable equipment.

Another tradeoff? Yes! Define it precisely.

Do you see other reasons? Which are usually valid and which are not?
3.45 It is often believed that storage areas are four walls with a lock on the door. In fact, conceptually, any area where equipment is stored represents a storage area. For instance, a desk may represent work space when the typewriter it supports is used, and a storage area at night when it is not used!

3.511 **Proper Use:** Efforts at the acquisition stage are aimed at obtaining equipment which will be suitable for the intended purpose. The level of knowledge about how to use properly the equipment purchased will have an impact on the extent to which these efforts will have been worth it in the first place.

3.512 An adequate usage lengthens the useful life of equipment and the time between planned maintenance periods, reduces injury hazards, and increases the productive use of equipment. Safety is particularly important, because injuries are socially and economically costly to society.

3.513 Proper use is an objective which should be planned. Not only is it not necessary to wait that equipment actually arrives at the RDI before doing any planning on proper use, but it is not suggested to do so.

3.521 **Training:** Adequate training of personnel is the single most important step to ensure that equipment will be used properly. It also contributes to reduce most of the hesitation, fear or reluctance of many potential users in using a piece of equipment. In certain cases, when there is no training, it is possible that only one or two persons actually end up using the equipment.

3.522 Instruction on how to use adequately a piece of equipment can initially be done with the use of graphs and with recommendations from knowledgeable individuals. Personnel could be asked to read booklets—not manuals—of instruction before the acquired equipment arrives. The same steps could be used for personnel unfamiliar with equipment already in use, although in such circumstances there is a strong tendency to rely on other users.
3.523 Users manuals can be very useful in providing instruction and should be read before using equipment. But practice shows that their usefulness before actual use of equipment is rather limited, although many users tend to refer to them at a later stage, when they encounter problems or are interested in knowing the capabilities of the equipment. Obviously, this initial reluctance is more so in the case of sophisticated equipment, due to the thickness of some of these manuals.

3.524 Many persons are inclined to use equipment by themselves before knowing exactly how it works. Although this type of learning allows for learning by doing, it might require more time than would be the case under proper guidance and it could even cause damages to equipment.

3.525 Suppliers sometimes provide a technician for a period of up to two weeks to train RDI personnel on the use of equipment recently acquired. When only one person trains the others, it is more likely that all trainees will receive exactly the same instruction, and that less misunderstandings are likely to occur than otherwise.

3.526 Even if this technician demonstrates how to use such equipment and what the minor operating problems can be, difficulties are likely to arise after he will have left. In such circumstances, personnel of the maintenance department are expected to provide support to users. Therefore, it is important that they get training too. Their training should comprise not only how to repair equipment, but also how to use it. Otherwise, how can they know if it is properly repaired or not, unless they count on users, who have other activities to perform than to sit and watch the repairs being done.

3.527 Once in a while, it can be expected that the nature of the research — sometimes at the forefront of knowledge — going on in many RDIs, will imply the acquisition of equipment which is not perfectly understood by the supplier himself. It is obvious that more problems are going to arise and less support be given by the supplier. It

In your opinion, what percentage of users fall into this category? Do you fit into it?

Proper training is indeed a must for maintenance people.

Did it ever happen in your RDI? If so what were the consequences?
should be clear to all that the decision by top management of the RDI to go ahead with the purchase anyhow, implies more risks than the purchase of a standard piece of equipment.

3.531 Longer Useful Life: The use of RDI equipment in general, and particularly of scientific equipment, should be restricted to authorized users for use only in prescribed circumstances. For instance, personal use of RDI vehicles should not be allowed. As an indication, the more costly or difficult to operate the equipment is, the smaller the number of users should be.

3.532 Although manufacturers build most equipment with more capability than what is stated in their warranties, it is suggested that equipment be used as recommended by manufacturers, including conditions of use such as temperature and speed or weight limits. For example, motors should not be run at their maximum speed, because it reduces substantially their useful life. Warranties usually cover only a limited time span, and should not be thought of as full shields against what might happen under whatever circumstances.

3.533 The running-in period corresponds to a period of time during which mechanical and electronic components of equipment begin to be used. This period is tough on equipment, because these parts have neither functioned together nor been tested over a long period of time. Proper running in, particularly in the case of mechanical components, impacts positively on the useful life of equipment.

3.534 Due care is appropriate not only for individuals, but for equipment also. It has been said previously that allocated — as opposed to pooled—equipment provided more incentive to use equipment properly. It does also increase the likelihood that users will give feedback to the purchasing department, so that it gets known whether equipment from a given manufacturer is satisfactory or not.

3.535 Proper maintenance of equipment represents a very interesting way to lengthen the
useful life of equipment. Because of the need expressed by most R&D managers interviewed during fieldwork, many pages will be devoted to that topic.

3.611(a) **Equipment Maintenance:**
Maintenance of equipment and maintenance of buildings (Chapter VI) have many aspects in common, when we consider that both topics deal with maintenance per se, its justification, its frequency, etc. Therefore, each notion will be detailed in the most appropriate chapter, and summarized — if necessary — in the other chapter.

3.611(b) However, due to their importance and to the extent of their relationship, it is strongly recommended that both sections be read in conjunction one with another. This topic was one of the most important ones according to many top officials interviewed, and it will be treated accordingly. It is expected that readers and participants of all levels will find interesting aspects to apply to their R&D, because the level of the discussion covers a wide scope of topics, both in number and in scope.

3.612 All types of equipment tend to deteriorate over time, or will break down at one point or the other. In fact, the more complex a piece of equipment is, the more likely it will fail rapidly, due to the high number of components. Components too tend to fail over time.

3.613(a) **Preventive maintenance is a struggle against deterioration and, the number and importance of unexpected failures.** It tends to extend the period during which an equipment will work properly, e.g. its reliability.

3.613(b) In fact, it aims at keeping equipment functional at an economical cost, and safe, by the identification of the actual and potential causes of failure and safety hazards, and their prevention. It should not be assumed that equipment in good working condition does not need servicing.

3.614 However, even exaggerated preventive maintenance does not guarantee that equipment...
will work properly without failures or major overhauls. For instance, changing motor oil of tractors every 100 hours of functioning makes operating conditions of the motor easier, but mechanical problems can still happen.

3.615 Reliability of equipment represents one of the key objectives of preventive maintenance (PM). Reliability is obtained by the extent to which it is built-in at the time of acquisition, and by maintenance. Once equipment is acquired, only maintenance can influence it.

3.616 It is important to insist on the fact that PM differs from corrective maintenance (CM) by one major aspect: PM is planned, while CM is not. Both aspects taken together constitute maintenance management.

3.617 Definition: Maintenance management corresponds to decisions taken relatively to the nature, scope and frequency of preventive maintenance, taking into consideration an equilibrium with the costs of corrective maintenance. Proper maintenance decisions correspond to pay less beginning soon, or much more, later. Figure 3.4 shows that, from an economic standpoint, the optimal point for preventive and corrective maintenance is situated where the total of both maintenance costs is the lowest. This concept will be developed in a subsequent section.

Figure 3.4. Determination of the Optimal Level of Preventive Maintenance - Equipment
3.618 Maintenance strategies fall into two categories: those which reduce the frequency of failures, and those which reduce the importance of failures. Preventive maintenance and equipment design fall into the first category, while adequate spare parts inventory falls into the second.

3.621 Extent of Emphasis: Amounts allocated through budgets reflect clear choices made by management. Therefore, it is important that annual budgets include adequate amounts for preventive maintenance, and that these amounts be used only for that specific purpose. Otherwise, efforts for proper PM will have been made partly in vain, and many savings to be realized through PM, will simply not be realized because PM budgets are exhausted for the year.

3.622 It is not as difficult as it seems to plan maintenance costs, because budgets are not intended for a complete accuracy, but rather for an allocation of funds. If preventive maintenance is planned, then most of the activities which will be performed are already known. Therefore, these activities, including major planned overhauls, can be planned. Corrective maintenance budgets may be based on previous years figures, adjusted for modifications in preventive maintenance policies, and for variations in the quantity and age of equipment.

3.623 Budget cuts have an impact similar to the one insufficient budgets have. If preventive maintenance is reduced or eliminated due to restrictions of funds, the message to users and maintenance personnel is clear: top officials do not believe enough in the advantages of PM to support PM in difficult times.

3.624 When there are liquidity problems, it is tempting to “save” on preventive maintenance, because the costs of such a decision are not obvious. In the short term, little impact will even usually be noticed. Figure 6.4 in Chapter VI illustrates the impact of that decision. If it has already been determined that the level of preventive maintenance was adequate, reduced PM is not justified on an economic basis. It is indeed the proper selection and timing of all PM.

Re-read this paragraph. It is not as obvious as it looks like. However, it provides a useful insight as to the role of PM as opposed to the role of spare parts.

This type of message is worth more than all procedures and recommendations.

Why do we write “save” rather than save?
activities which result in the advantages of doing an appropriate level of PM.

3.625 Preventive maintenance will be planned and performed only if it is believed that it is important for the efficiency of the RDI operations to do so. If top officials in particular are not convinced of the importance of PM, it is doubtful that most of the potential savings will materialize, because efforts will be made in other areas.

3.626 It has been demonstrated time and again that properly planned and performed PM could reduce substantially total costs of maintenance and repairs. Why would RDIs be different? Because the relative importance of PM and CM may vary substantially among RDIs, the level of PM should be assessed carefully, and overall policies determined accordingly.

3.627 Although there could be theoretically too much PM, this situation seldom occurs in practice, mostly because of all other areas competing for funds. Besides, it might not even be noticed.

3.628(a) Considering that breakdowns are costly; that proper maintenance management could help improving the financial situation of RDIs, and that PM usually represents only a small portion of acquisition cost, it is surprising that little PM is performed on equipment in most RDIs. Some of the reasons to be thought about are lack of knowledge, excessive preoccupation with other RDI activities, small number of properly trained maintenance mechanics, and easiness to get funds for unplanned repairs as opposed to planned maintenance.

What is your opinion on this issue?

3.628(b) Although most RDIs have laboratory, automotive and office equipment, it was noticed during fieldwork that in some RDIs PM was limited to motor vehicles mainly. It is not logical to determine a PM policy for some equipment, while neglecting to have one for other types of equipment.

Why does this situation exist then?

3.629 It is difficult to change overnight the pervasive philosophy of “If it works, do not fiddle with it”. Assuming that top RDI officials think that

Is this philosophy currently used in your RDI?
repairs are too costly and that it is worth the effort to increase the level of PM, where should maintenance personnel put their efforts?

3.631 **Beginning PM:** When evidence has to be provided rapidly that PM is really worth it in financial terms, but also because it reduces the number and importance of unplanned interruptions, there are a few principles which should be followed.

3.632 If little or no preventive maintenance exists, begin the PM programme progressively, rather than rapidly. This will allow the person responsible for maintenance to do better planning and control than would be the case if all PM operations are begun at the same period.

3.633(a) Preventive maintenance programmes should be focused initially mostly on equipment which fails often or for which the cost of failures is high. It is likely that mostly the same equipment will fall into both categories. When this is the case decisions about which pieces of equipment to examine first are made even easier.

3.633(b) **Definition:** The 20–80 rule, also known as Pareto's law and as ABC analysis stipulates that 20% of the items under study usually account for 80% of the occurrences that are of interest. In this case, 20% of the machines should account for approximately 80% of the total number of failures. Similarly, 20% of the causes of failure likely account also for 80% of the failures, a situation illustrated in Figure 3.5. This empirically-based rule should be used for planning maintenance operations.

3.634 It is important to define well the activities to be performed as part of a PM programme. It is indeed likely that these activities will not be revised frequently thereafter, unless problems occur or revisions are made periodically to the PM programme. Therefore, it is worth the effort to examine the equipment register and the users' manual — when they exist and can be found — in order to determine which maintenance procedures would seem the most appropriate and what their frequency should be.
When PM operations are performed but give poor results, it is important to determine whether unsatisfactory maintenance is mostly due to insufficient or to poorly done maintenance. In the first case it is a matter of putting the emphasis on more PM, while in the second, efforts should be oriented more towards better training of the maintenance crew.

**Maintenance Timing:** Corrective maintenance reduces the extent of planning required to incorporate preventive maintenance activities to the activities schedule of RDI departments. However, the timing of CM is not often appropriate, due to the too obvious reality that CM activities are not planned.

Although PM represents a good opportunity to plan both the RDI usual operations and maintenance activities, such planning might prove to be difficult at times. Proper coordination is possible when the user department is told ahead of time when PM is planned and on which equipment. Such a coordination is important, because there is no major immediate difference for users between having to delay operations for maintenance they have not been told about, and for repairs.

Fortunately, it is to the advantage of both departments to cooperate. Besides, a maintenance schedule is somewhat flexible, although one of the...
major reasons for doing PM in the first place, is to respect such a schedule as much as possible.

3.644 There are adjustments other than operations of the user department, which might justify minor modifications to the maintenance schedule. To do PM on similar equipment successively makes sense when such equipment is used in similar conditions, because maintenance personnel are familiar with the nature of the maintenance operations to be performed. However, conditions and extent of use are not necessarily the same for similar equipment.

3.645 Whenever possible, maintenance should be performed when equipment is not in use. Doing so reduces disruptions to regular activities in the user department. Sometimes, it could even be indicated to carry some of the maintenance operations at night.

3.646 It is often recommended that CM be performed as soon as a problem is known. This may not be necessarily appropriate. For instance, maintenance staff might decide that slowly leaking oil does not warrant to stop a machine. Corrective maintenance could then be planned accordingly. It is sometimes costly to have important equipment idle due to CM, and possibly, only a short while later for PM.

3.647 Circumstances do not always allow for such planning of CM. Sometimes, equipment has to be repaired rapidly. When repairs are urgent, some members of the maintenance crew leave the repairs they are doing in order to proceed to do urgent repairs. Obviously, this is more costly than when time allows at least to complete the job being done at that time.

3.648 When a failure occurs, it might be appropriate to consider an overhaul, if one is due soon. The failure might indeed necessitate to perform some steps that will have to be repeated for the coming overhaul.

3.651 Spare Parts: All types of inventories are costly. The tradeoff is the following: to have a larger variety and more spare parts, or to incur a
greater possibility that the type or quantity of spare parts needed are not immediately available. It should be noted that inventory of spare parts should be kept to a minimum in order to avoid tying up money which would have been used better elsewhere. Also, high inventory requires more space for storage.

3.652 Deciding about this tradeoff, and also about a policy as to the type and quantity to be held in inventory represent major decisions. Most aspects about these decisions will be discussed in more detail in the following chapter.

3.653 Spare parts inventories should be managed as properly as other inventories required by the RDI. For instance, centralization of spare parts in one store allow for better control on types and quantities on hand than when this is not the case, but implies more travelling for personnel.

3.654 A significant part of the maintenance function is the existence of spare parts. There is therefore need to ensure that an adequate, but not excessive, supply of frequently used spare parts is available in the stores or locally. In the case of spare parts used in smaller quantities or which are more expensive, the decision is even more difficult. Exercise 3.3 provides a situation showing that this type of decision is not easy.

Exercise 3.3: An actual maintenance situation

Situation:

An important agricultural vehicle has just been dismantled. It is discovered that the two parts that are broken are not available at the local dealer. The situation is critical for two reasons:

(1) Space is already a problem in the garage; what should be done with the dismantled machine, until it gets repaired?

(2) It is at this time of year that this machine is needed the most. What could be done to alleviate or solve this problem?

Why is it more difficult?
3.655(a) The quantity and type of spare parts to maintain in inventory depend on numerous factors. How close is the supplier to the RDI? If the proximity is sufficient, then it is justified to count also on the supplier's inventories. In fact, proximity is assumed to be related to distance rather than to time, but this is not necessarily the case. For instance, it is sometimes possible to get important parts from an overseas supplier within a few days.

3.655(b) The type of parts held in the suppliers stores and the availability of those parts should influence the inventories stored at the RDI. It should not be taken for granted that a supplier situated close to the RDI has all parts available. How is it possible to do a reasonable job in determining what is held in stock by key suppliers, without checking for each item required in an RDI?

3.655(c) The most likely parts to fail are the ones that are needed the most often. Therefore, they should be on hand at all times. The determination of such parts is based on the users manual, previous experience with similar machines, and on judgement. Utilization patterns could be useful too!

3.655(d) Other factors with an impact on the quantity and type of spare parts, and already mentioned or alluded to in this chapter, include: cost of a failure, available funds, planned preventive maintenance and overhauls, and number of machines using such parts. These factors are all important. Try to relate each of them to the quantity of spare parts. How is it possible to make an overall decision?

3.656(a) A special case arises for special purpose equipment. It is likely that the supplier does not hold all spare parts in large quantities. Therefore, when demand is higher than expected, the supplier might run out of stock for a part which is not produced very often. For special purpose equipment, it is usual to ask the supplier to include a sufficient supply of spare parts at the time of delivery.

3.656(b) Reliable suppliers also advise their clients as to lead times required for most parts not held in their inventory, and which fail during the expected useful life of a machine. It will then be the RDI officials decision as to the risk they are willing to take that the most required equipment does not have all spare parts available. They will provide a general policy, while the person
responsible for maintenance will take the specific steps to ensure that the stated policy will be followed.

3.661(a) Frequency of Preventive Maintenance: Frequency of PM is not just simply decided once and for all. It should be revised periodically, to ensure that it is still appropriate. For instance, failures occurring within a too short period of time might indicate that there is not enough PM done, or that it is poorly done.

3.661(b) In practice, it is about impossible to determine accurately the adequateness of maintenance policies. This is particularly so in the few instances where too much PM is performed, because the impact of less PM on the number of failures is not always known.

3.661(c) A similar situation arises when new equipment is acquired: despite the manufacturers potential recommendations, it is difficult to define what an appropriate PM policy should be. Then, one could ask: For how long should we compile information to be sure about our PM policy? The answer is: You might never know, unless sufficient information has already been compiled for similar machines. Fortunately, some generalizations exist which allow to know quite precisely when failures tend to occur.

3.661(d) Frequency of PM should be influenced by a stated objective as to the percentage of uptime of equipment. Uptime is the percentage of time during which a given equipment is available for the intended use.

3.661 (e) Overall, it can be said that the frequency of PM is a matter of well-informed judgement, taking into consideration mostly the extent to which RDI managers are satisfied with the existing one (although it may vary for each piece of equipment). But there should be other important considerations, as will be discussed and detailed in the coming paragraphs of this section.
3.662(a) **Definition:** A distribution of failures is a graphical or arithmetical representation of the frequency of failures over time. When such a distribution exists, it can provide information as to the periods during which it is preferable to perform more PM. However, it does not tell the number of times that such PM should be carried out.

3.662(b) The three most frequent types of failure distribution are known as negative exponential curve, normal curve, and bathtub curve. Each type will be discussed successively.

3.662(c) The negative exponential curve is represented in Figure 3.6. It is a distribution applicable to most machines that are somewhat complex or that include electronic components. Often, this type of machine indeed tends to fail soon after it has been acquired or repaired, mostly because it requires to be perfectly adjusted during the running-in period. Once this critical period is over, it is less and less likely that this type of equipment will fail.

**Figure 3.6. A Negative Exponential Curve**

3.662(d) It is difficult to accept that a machine which has just been repaired stands a higher probability (chance) to fail than one which has not been repaired for a longer period. But distributions like this one originate from observed phenomena and, consequently, might well be applicable to most sophisticated equipment in RDIs.
3.662(e) The implication of the negative exponential distribution on maintenance of equipment following such a distribution is simple: it is better to perform maintenance frequently when a machine has been recently repaired, while it is not necessary to do it as often subsequently.

3.662(f) The previous observation does not imply that maintenance should be neglected. For instance, cleaning and lubrication could contribute to lengthen the reliability of such equipment. However, there is a clear indication that the changes of parts should be limited mostly to those which follow either a normal curve or a bathtub curve type of distribution.

3.662(g) The normal distribution is the second type of distribution of failures which is useful for the frequency of equipment maintenance. It corresponds mostly to simple machines. This type of equipment indeed tends to fail less frequently when it is new, and more often afterwards, until the frequency of failure reduces again. Figure 3.7 illustrates a normal curve.

Figure 3.7. A Normal Curve

Once you have read the paragraphs concerning those types of failure distribution, come back to this last sentence and think about it!

3.662(h) Decisions related to maintenance for such equipment are to be made in close relation with the cost of failure. For instance, if it is observed that a given type of equipment tends to fail, on average, after 400 hours of use, it can be expected that, if PM is done every 400 hours, half of the times machines will have failed before PM is done.
3.662(i) It should be noted that many parts follow a normal distribution, because a part is usually quite simple. Therefore, the maintenance crew and particularly the person responsible for the maintenance department, should make a distinction between individual parts and the entire piece of equipment.

3.662(j) The third type of distribution is called the bathtub curve, due to its shape, shown in Figure 3.8. This distribution is particularly applicable to automotive equipment. It represents equipment with a high early failure rate, due to the running-in period. Subsequently, fewer failures are experienced, until equipment begins to fail because it is nearing the end of its useful life.

Figure 3.8. A Bathtub Curve

3.662(k) In such circumstances, PM must be performed mostly in the early and late stages of the expected useful life of equipment, because it is then that failures are more likely.

3.662(l) In practice, it is not necessarily easy to determine when the frequency of PM should be modified to suit the distribution of failures. However, efforts should be made to take into consideration known distributions, because they can reduce drastically the level of guessing going on with PM planning.

3.663(a) Definition: Simulation is the representation of an actual situation in order to make decisions. It is useful to know that simulation can be used for maintenance. For instance, when you think about the outcomes of a given situation, you are simulating it: you do not try out all options on the actual situation!
instance, historical data could help to determine the impact of hypothetical PM on the frequency of failures. It could also be used to determine the impact of an increase in the size of the maintenance crew on the number of machines expected to be out of use.

3.663(b) Simulation is mostly used with computers, although it can also be performed manually. However, this topic will not be covered in more detail in this Manual, because of its scope and prerequisite in terms of statistics, together with its likely limited use in most RDIs. Persons interested in simulation can refer to any textbook on the topic.

3.664(a) Additional Maintenance: Difficult conditions of use should lead to more PM than usual. For instance, a vehicle going on a long field trip must be properly serviced before departure, particularly for a trip in an area such as a desert. Servicing includes all maintenance and inspections appropriate under the circumstances.

3.664(b) It is surprising how much small steps such as lubrication, oil and filter changes, and even cleaning, can improve the reliability of equipment. This is why it is preferable to do a little more than a little less maintenance.

3.665(a) Optimal Maintenance Costs: It is clear that more PM reduces the number of failures, but costs money. On the other hand, less PM saves money on planned PM, but increases the costs related to the additional failures likely to occur. What represents a desirable equilibrium between PM and CM?

3.665(b) When no PM is performed, all maintenance costs are CM costs. None of the benefits of PM are harvested. Doing just a little PM could help to reduce substantially the CM costs. At the opposite, it is very costly to do so much PM as to incur CM costs very seldom. Therefore, there is bound to be an intermediate point where an equilibrium is reached.

3.665(c) Figure 3.9 represents graphically such a point. If we assume that PM costs are linear—e.g.
3.665(d) Some other important considerations on maintenance frequency should be remembered. Based on the figure, it is less costly to do more PM than less, at an equal distance from the optimal point. This shows up in the shape of the total cost curve, because it increases less rapidly on the right than on the left of the optimal point. This confirms what was previously deduced.

3.665(e) It can also be determined that when failures are more costly than expected, more PM should be done. This reality can be observed graphically by drawing a CM curve over the existing one; as a consequence, the optimal point moves to the right.

3.665(f) Another important observation is the fact that the zone around the optimal point is rather flat. This implies that it is not very costly to do more or less PM, as long as the frequency with which it is carried out is not too far from the optimal point.

3.665(g) Finally, it should be clear that, from an economical standpoint, more PM is not more costly than less. It could be represented both costs as curvilinear. Both shapes could be valid, depending upon circumstances. Which shape would you mostly argue for?

Remember: It is LESS COSTLY to do more preventive maintenance than less. Convince yourself by examining the shape of the total cost curve. Try it and remember the message!

This sentence does not contradict what is said in paragraph 5.665(d).
necessarily always better than less. For instance, a little bit less maintenance than optimal is better than much more than optimal. It is even possible that when the cost of failures is very low, little PM is required. Each, situation should be examined separately.

3.666 When failures occur before PM activities are performed, it is suggested that PM be done as planned. It is often thought that repairs should postpone PM. This is indeed a trap that many fall into. But the total cost of maintenance already considered a given frequency of PM and that some CM costs would be incurred. Accordingly, PM activities should be done as per schedule.

Think twice about it!

3.667 It should be emphasized that the determination of a proper PM frequency begins with the estimation, and whenever possible, with the computation of PM and CM costs. If no attempt is made in that direction, it will be very difficult to know if the frequency is reasonable.

3.671(a) Responsibilities: It takes people to carry these PM and CM tasks, whatever the frequency of PM opted for. Who will make these decisions regarding the assignment of tasks? Where will this person fit within the organization? His place in the hierarchy could indicate the importance of maintenance to management.

3.671(b) Being responsible for buildings and for equipment, it is normal that the Estate Officer be responsible for maintenance also. However, fieldwork pointed out that quite often the maintenance responsibility was not clearly established. As a result, maintenance was not necessarily adequate, and it was not always initiated as rapidly as it should have been.

3.672 Inside or Outside Maintenance: This choice has more implications than it looks like. For instance, internal staff know most of the equipment in the RDI, although not necessarily in detail. Also, an internal team is under the direct authority of an RDI official, who can decide upon the urgency of CM tasks and assign staff accordingly. On the other hand, outside contractors can do work that cannot be done inside.
due to excess of maintenance work in the RDI or to the level of expertise required. Contractors are more costly, but they do not represent a fixed cost.

3.673(a) Basic maintenance activities (whether PM or CM) can be performed by users themselves. This approach makes planning easier, and allows users to really feel responsible for properly operating and servicing equipment they work with. On the other hand, users are not hired to do various maintenance tasks, and it could be a poor use of their time to ask them to do these tasks. For instance, scientists could spend valuable time in trying to fix something they are not knowledgeable about, while members of the maintenance crew could fix it more rapidly. Figure 3.10 can be used as an indicator as to who should repair equipment.

3.673(b) So, unless it is a minor problem or maintenance activities which do not require much time, it is better to let these jobs to maintenance personnel. However, it is expected that users will collaborate with them not only to report a malfunction, but also when difficult conditions of use are expected.

Figure 3.10. Responsibility for Repairs

<table>
<thead>
<tr>
<th>Type of problem</th>
<th>Responsibility</th>
<th>Skill level (considering the type of problem)</th>
<th>Time required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very minor</td>
<td>Operator</td>
<td>Limited</td>
<td>Little</td>
</tr>
<tr>
<td>Minor or major</td>
<td>Maintenance crew</td>
<td>Competent</td>
<td>Longer</td>
</tr>
<tr>
<td>Very major or warranty</td>
<td>Supplier or contractor</td>
<td>Specialist</td>
<td>Much longer</td>
</tr>
</tbody>
</table>

3.674(a) An internal maintenance crew can sometimes represent an important cost for the RDI. Therefore, this is an additional reason why proper planning of maintenance operations is necessary. It
is even possible to control the time required to perform maintenance tasks by comparing these with established standards. However, before reaching this point, it is suggested that the effectiveness of maintenance—the adequateness and frequency of the activities performed—be controlled first.

3.674(b) An internal maintenance group without appropriate training is similar to good equipment without spare parts: the idea is very good until adverse conditions really allow to test the appropriateness of managerial decisions such as the amount of training and the quantity of spare parts really necessary to face the problematic situation.

3.674(c) It is imperative that the maintenance crew members be trained to perform all activities that the Estate Officer wants them to do. This implies that they should be familiar not only with minor problems, but also with major overhauls if this is required. For instance, the RDI could well be situated far from competent outside sources; in such a case, it might be appropriate to have some members of the crew trained to fix major problems.

3.674(d) If the number and complexity of equipment problems warrant to have maintenance people specialized in certain types of machines, then special training with suppliers might be required.

3.675(a) In some RDIs, it is one of the Ministries which has the responsibility for all types of maintenance. This limits the decision making power of RDI officials. However, it is sometimes necessary to do maintenance and repairs before they are done by the Ministry. In such circumstances, the RDI has to incur the cost without having the authorized budget.

3.675(b) The only alternative left to RDI officials is to convince the Ministry about the appropriateness of PM as opposed to CM, and about the need to fix equipment rapidly in order to improve the efficiency of operations in the RDI (and indirectly in the country); this is not an easy task.
3.676(a) Suppliers constitute another source of external maintenance. For instance, office equipment—including computers—is usually covered by service contracts. During the warranty period, the supplier takes upon himself all maintenance and repairs, at no cost for the RDI. After the warranty period is over, these costs are transferred to the RDI, unless a service contract is signed, which provides advantages similar to a warranty, but at a cost to the RDI.

3.676(b) The cost of maintenance is known completely when the service contract includes both parts and labour. It is only partly known when it includes only labour. In general, there is virtually no way of ensuring whether repairs and maintenance have been performed satisfactorily. In fact, it is only by using equipment that it will be possible to say so.

3.676(c) When there is no service contract, calling in suppliers can be quite expensive. Accordingly, it is appropriate for the internal crew to determine if the nature of the problem appears to be beyond their competence. If this is the case, a repairman can be called in. In certain circumstances, it is appropriate to have that person inspect all other similar machines and even to overhaul some of these.

3.676(d) It should be noted that it is usually not a sound decision to have all complex maintenance work done internally, because the cost of expert maintenance people working for suppliers might be less overall, and the job might be done faster.

3.681 Maintenance Records: Judgement has an important role to play in maintenance decisions, as it does in other types of managerial decisions. However, when judgement is also based on facts rather than only on impressions, it is more likely that these decisions will be appropriate. Up-to-date records can provide accurate information needed to take decisions about maintenance.

3.682 Most information about records is in section 3.3. A few aspects were kept for this section, in order to relate these even more closely to the theme of this section, e.g. maintenance.
First, updated records can provide much useful information to outside contractors who are not familiar with all the maintenance and repair work done on specific equipment. They could see rapidly what some of the potential causes of the problem are.

Second, records could be used to note down the assessment of the extent of use of equipment. While this assessment is relatively easy for automotive equipment, it is more difficult for scientific equipment. The extent of use can be estimated by discussing with users of allocated equipment and, in the case of pooled equipment, by examining the equipment loan register.

Third, computers are used mostly to accumulate information. However, they could be used also to help in scheduling maintenance operations. Proper records of job assignments could then be easily available.

Finally, it could be useful to summarize maintenance steps contained in users manuals. This procedure would reduce time lost due to identifying where to look for such information in the book, and it would more likely be read than a users manual. It appears more appropriate to leave such maintenance summary information with the maintenance department when it is well organized, than with the users.

Valuation: Original cost includes acquisition, transportation and installation costs. The original cost is depreciated (reduced) every year in order to reflect a loss of value, while major repairs which lengthen useful life are added to the depreciated value of specific equipment. Depreciated values seldom reflect replacement costs, because they do not aim at the same purpose.

Original cost becomes more or less relevant for future decision purposes because it is a sunk cost, e.g. it has already been incurred. However, depreciated values could provide useful information as to the necessity to replace equipment in the coming years. This is indeed true when depreciation bears a sufficiently close relationship with expected useful life.

Do you really believe that up-to-date records could save time to contractors? Justify your position.

The concept of sunk cost is essential for equipment replacement. Can you provide an example of a sunk cost and explain why it is no more-pertinent?
3.73 Replacement costs, original costs and depreciated values are not as useful when they are not written down, because information based on memory is usually not as accurate, even when it is not simply forgotten. Therefore, it is recommended that the equipment register already described in a previous section includes depreciated values and replacement costs whenever possible.

3.74 Replacement costs are particularly useful for expensive equipment and for equipment which is up for replacement. They make the planning of equipment to be acquired or repaired easier. It should not be forgotten that all authorizations for the acquisition of most capital goods may require up to a year, and sometimes more.

3.75 Replacement costs are not simply a percentage added to the previous year replacement costs. They might require a gathering of information with suppliers. All information costs time and money. Therefore, the cost for obtaining information on replacement costs must not outweigh the benefits derived from it.

3.811 Equipment Disposal: Useful life of equipment can be lengthened by adequate maintenance and proper use. However, there comes a time when even very good equipment gets less and less reliable, and costs more and more to repair. A major repair job to be done on spare parts which are more and more difficult to get, can also raise the issue as to whether a piece of equipment should be disposed of or not.

3.812 Sometimes it is the acquisition of new equipment which forces the disposal of older equipment which is still appropriate for the intended purpose.

3.813 The accumulation of unserviceable or obsolete equipment which should have been disposed of long ago, has a negative impact on personnel and uses up costly space. This is why disposal procedures should be clearly established and adhered to.

In your RDI, are replacement costs known for major equipment?

How does it have a negative impact on personnel?
3.814 There should be a periodical comprehensive inspection and assessment of the serviceability of all equipment in the RDI. Future serviceability and useful life should be assessed before overhauls are done. This will help to determine whether equipment should be repaired or replaced. Overhauls normally extend the useful life of equipment, and may require a re-examination of the frequency of PM.

3.815 Serviceability is mostly related to reliability and to the overall cost of repairs and maintenance. A rule of thumb could be used to help to assess serviceability. One such rule could state that a machine should be replaced if its maintenance and repair costs exceed 25% of the acquisition cost.

3.816 There are two types of approaches used to make decisions about the serviceability and disposal of equipment: to let users decide, and to wait for Boards of Survey.

3.821 Users: The basic reason to let officials decide about disposal is to let decision-making into the hands of those who are best placed to know whether equipment should be disposed of or not. When the decision is made to dispose of some equipment, a designated person should inform an appropriate individual in the purchasing department.

3.822 Disposal decisions are obviously not the same whether the equipment to be disposed of is a vehicle, a typewriter or a sophisticated piece of equipment, such as an electronic microscope. The head of the department with items to be disposed of, and not members of his staff acting on their own, is often the person authorized to make such decisions.

3.831 Boards of Survey: This is the type of approach used in many RDIs. The main purpose of such a Board is to assess the state of equipment, particularly to identify obsolete, unserviceable or old equipment.

3.832 It should be recognized that these could represent very different tasks for the Board.
members. To identify obsolete equipment often implies that newer types of equipment and some of their characteristics are known. Unserviceable equipment cannot be repaired; members will likely often rely on users, maintenance or purchasing personnel to know that it is the case. Finally, old equipment can be identified by looking in the equipment register for the dates of acquisition.

3.833 It is a good idea to tour the premises and to ask questions on the use of some pieces of equipment which appear to fall into one of the three categories above. Dusty equipment, particularly when it is away from the department it should be in, is one indication about ways to identify what is aimed for.

3.834 Fieldwork revealed that Boards of Survey were directed at motor vehicles primarily and that they did not meet on a regular basis, and in some cases, had not been appointed for a long time. Therefore, it is questionable how effective they are. Considering the lack of space in most RDIs, it is surprising that these boards do not play a more regular role in the disposal of equipment and are used mostly for one type of equipment only.

3.835 The low frequency and lack of regularity of Boards of Survey is not surprising if there is no clear assignment of responsibility for initiating the call of the board. Similarly, if such a call is made by an overloaded official or involves busy individuals, such meetings might be delayed unduly.

3.836 When the Board of Survey is appointed by governmental authorities, delays are not due to the RDI which should be visited. It is then suggested to request more than once that such a board be appointed and, eventually, to store away equipment which is not used, until the board meets.

3.841 Disposal Options: There are at least four options available to RDIs when comes the time to dispose of some equipment. These options are available, unless disposal of old or obsolete equipment has to follow government regulations, rather than RDI decisions.
3.842 First, older equipment can be traded in. This is a common option for vehicles, computers, and office equipment. The price paid by the supplier of the new equipment is usually less than what would be obtained by selling it directly to other potential users. However, it saves time in finding a party who would be interested in buying the equipment to be disposed of.

3.843 It has been observed in many RDIs that old equipment is kept even when it is displaced by new one. It is often an illusion to keep it just in case it will be used again, because people tend to forget its existence. Therefore, it should be traded in or sold, while there is a better chance to find a user and to get a better price than by waiting in a few years. It is even advisable to establish a policy stating that old equipment has to be traded in, unless it is going to be used on a regular basis by users within the RDI (not necessarily within the same department).

3.844 Secondly, equipment may be sold instead of traded in. It is then suggested that a person within the purchasing department be responsible for selling the equipment at the best price that the market will bear. The advantage of doing so is to avoid giving an additional responsibility to the official in charge of the department with items to be disposed of.

3.845 It should be recognized that it is not always easy to find a buyer for used equipment, particularly when such equipment is sophisticated. However, the channels for the sale of used equipment — when they exist — are limited, although they are not the same for all types of equipment. For instance, motor vehicles can sometimes be sold to staff or at a public auction at a fair market price, while a centrifugal machine might be useful only to a few other RDIs in the same country or in the neighbour countries.

3.846 Another advantage of having a specialist to sell used equipment, is the likelihood that this individual will know when used equipment required by the RDI will be put for sale by other RDIs or by other sellers.

Is it a characteristic of your RDI also?

In your RDI, is used equipment sometimes sold or is it nearly always stored away and scrapped?
3.847 A third way of disposal is to scrap unserviceable or obsolete equipment. Although prices offered are usually low, the equipment will have been disposed of by taking into consideration that other buyers were rather unlikely.

3.848 The fourth way is not as such a disposal, but rather a new use for the machine that was just stored away. If an RDI has many machines of a given make, and parts are getting difficult to get, it might be possible to use the good parts of the unserviceable equipment to repair other similar machines. However, there is a danger that the RDI looks like a scrap yard after a while.

3.849 Finally, RDIs could donate equipment to schools or to other institutions in need of such equipment.

3.91 Conclusion: As in the case of land and buildings, equipment is a resource necessary for the RDI to fulfil its mission. It has a useful life which can be lengthened by proper use and proper maintenance. The last one should be of particular interest, because it appeared that improved maintenance could substantially enhance productivity in most RDIs.

What are the 5 disposal options?

(1) __________________
(2) __________________
(3) __________________
(4) __________________
(5) __________________
PROCEDURES MANUAL OUTLINE—EQUIPMENT

I — GENERAL CONSIDERATIONS

1.1 "Equipment" consists of all fixed assets other than land and buildings. Thus it includes laboratory equipment, automotive equipment, furniture, computers, photocopying machines, typewriters, film projectors, filing cabinets, and all other items which have a useful life of at least one year.

"Taking on charge" means the entry of particulars of equipment in the applicable assets register or other record kept for this purpose.

1.2 Before the acquisition of the equipment for RDI, certain objectives are to be taken into account:

(a) The need for equipment which precedes the acquisition.
(b) Identification of storage space.
(c) Safety and control measures of equipment.
(d) Maintenance during the useful life of the equipment.
(e) The use of the equipment.
(f) Disposal of the equipment after its useful life.

1.3 An equipment register shall be maintained in which details of items of equipment shall be entered showing date, particulars, supplier, invoice number, amount, rate of depreciation, maintenance costs, repairs and overhauls.

1.4 Every item of equipment shall have an identification mark and a number assigned to it for the purpose of control.

1.5 Standardization is one aspect to be considered before acquisition of the equipment. It is preferable to purchase only one or a few different makes of equipment suitable for specific purposes. Thus, service from suppliers will have been experienced before regarding installation, availability of spare parts and maintenance activities and the reliability of the equipment.

1.6 Life cycle of the equipment must be taken into consideration at the time of purchase. Thus, resale value and costs of major overhaul must not be ignored.

II — PLACEMENT OF THE ORDER

The order will be placed for the purchase of equipment by the purchasing department after authorization of the Board of Management has been obtained.
I. — TAKING ON CHARGE OF EQUIPMENT

3.1 Equipment whether obtained by purchase, internal manufacture or grant, shall be taken on charge at a representative value. The relevant asset register or record shall, if applicable, indicate to which department or division of the RDI the equipment has been allocated, and what department or division shall be responsible for damage to or loss of such an equipment.

3.2 Every operator of equipment shall ensure that operating instructions of the equipment are strictly adhered to at all times.

IV. DETERMINATION OF THE VALUE OF EQUIPMENT

4.1 Equipment Obtained by Purchase

4.1.1 Imported Equipment: The purchase price of the item, together with expenses in connection with the importation, e.g. customs duty, commission, clearing costs and transport charges, shall be debited to the equipment account; provided that expenses such as railage and insurance shall not be so debited.

4.1.2 Locally Purchased Equipment: The purchase price and the transport charges of the items shall be debited to equipment account.

4.1.3 Accessories to the Equipment: All accessories to the equipment acquired at the same time as the item concerned, as well as later additions shall be debited to the account.

4.2 Equipment Manufactured by RDI

Equipment manufactured by divisions of the RDI, which on the basis of joint cost of materials and labour (calculated at the current labour rate for services rendered) qualify for calculation as equipment value, shall be debited to the equipment account at the calculated cost figure.

4.3 Equipment Obtained Through Grant

Laboratory or other equipment obtained by grant as well as items for which no capital equipment record exists (e.g. written-off items taken on charge again) shall be debited to the equipment account at an amount determined by the financial officer.

V. SAFEGUARDING AND MAINTENANCE OF EQUIPMENT

5.1 An officer entrusted with the capital equipment of the RDI shall ensure that such equipment is kept safely and maintained in good repair.

5.2 If the equipment is lost or damaged, such damage or loss shall be reported immediately in writing to the Estate Officer for appropriate action with the insurers of the equipment.
5.3 Except on the written authority of the chief executive or an officer designated by him and subject to such conditions as he may lay down, equipment of the RDI may not be lent to any institution or person outside the RDI for any purpose whatsoever.

VI—WRITING OFF AND DISPOSAL OF EQUIPMENT

6.1 Equipment may be written off only if it is:

(a) lost;
(b) obsolete,
(c) worn or if spares for it are unobtainable,
(d) uneconomical to operate;
(e) irreparably damaged,
(f) no longer needed,
(g) potentially dangerous for staff or operators or the public, e.g. if it possesses a fire or explosion hazard.

6.2 When a decision has been taken for the equipment concerned to be written off, appropriate action should be taken to have the equipment subjected to a Board of Survey who will make the necessary recommendations as to its disposal following thorough examination.

6.3 When the Board of Survey has recommended to have the equipment written off and the approval of the governing authority obtained accordingly, then the equipment concerned may be written off from the Assets Register.

6.4 Unless duly written off, equipment may not be sold, traded in, dismantled or in any other way disposed of or dealt with, in all cases the writing off of capital equipment shall be sanctioned by the governing authority.
EQUIPMENT: Selected readings for more study


MATERIALS

Training Objectives

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

1. Understand the importance of adequate stock records.
2. Relate stock records control with physical control.
3. Use FIFO, LIFO, and weighted average cost methods of inventory valuation.
4. Distinguish between inventory stocktaking and periodic spot-checks.
5. Explain why and how arbitrary inventory cuts can be damaging to regular RDI activities.
6. Apply the ABC method of resources allocation to materials.
7. Understand the Economic Order Quantity (EOQ), holding costs and ordering costs.
8. Identify the components of lead time and service level.
9. Explain safety stocks and reorder points.
10. Use fixed-order quantity method and fixed period method of materials ordering when justified to do so.
11. Explain MRP and JIT.
12. Discuss about the characteristics of storage areas.
13. Consider important aspects in inventory valuation and disposal.
MATERIALS

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This material should be covered in two sessions. One session could cover all aspects in
detail, except for section 4.3 which would be covered very briefly. The second session would
deal exclusively with section 4.3. It can be expected that it could be a difficult section for
many participants. Therefore, careful preparatory study is particularly important in this
case.
**CHAPTER IV**

**MATERIALS**

4.111 **Introduction:** Some materials like fuel facilitate fundamental work done in RDIs. Other materials like seeds or specimens are directly necessary to do the research activities specific to an RDI. Therefore, it is important that materials be managed properly in order to ensure adequate ordering and sufficient control.

4.112 This chapter is divided into seven topics. The first three — specific procurement procedures, inventory records and planning quantities, deal with aspects mostly related to the acquisition of materials. The second group of three — security, storage areas, and valuation, deal with physical and financial control of materials. The last topic describes some considerations in the disposal of obsolete materials. An outline procedures on materials is provided at the end of the chapter as a guide for important aspects to consider for materials.

4.113 **Inventory records** could have well been treated with the group of topics on control, as records represent an important control method. It is treated before the topic on planning quantities because of the close interrelation between both topics. It is indeed important to know quantities on hand before placing an order.
4.114 Once again, the interrelation of similar topics in different chapters must be emphasized. For instance, the topic of storage areas as initially discussed in the chapters on buildings and equipment obviously bears a relationship with the same topic in this chapter. However, some aspects which are particularly important for materials management are discussed here.

4.121 Definition: Materials are items and substances which can be considered as inventories once they are acquired. Some materials such as certain chemicals lose their properties rapidly, while others do not. Materials are considered as an expense, as opposed to equipment, which is usually more costly and can be repaired and overhauled.

4.122 Definition: Materials management is a set of methods and principles by which an endeavour is made to plan, organize, coordinate, control and review the flow of materials from the supplier to the final user. Materials control is further defined as a subordinate concept and covers the attempt to improve the attainment of the objectives with the given resources and materials present in the RDI.

4.123 Definition: In this chapter, inventories are quantities of unused materials owned by an organization and which are usually stored until their use. Inventories represent a temporary accumulation of materials which is costly, but believed to be advantageous, often with reason, by the owner.

4.131 Supplier Selection: Materials are purchased more frequently than equipment is. Therefore, there is more paperwork involved in total. If research workers and scientists would do it all, much less research would be done. Fortunately, a purchasing department can take care of user requests for materials, and deal with suppliers; people in this department become the experts in most areas of the procurement of materials. Centralization provides a better control over all these aspects.

Name a few important materials used in your RDI:
(1) ______________________
(2) ______________________
(3) ______________________

When are materials considered as inventories and when aren't they?

When scientists procrastinate against the purchasing department, they should think about this reality.
4.132 Materials constitute the largest portion of the purchases made in most organizations, including RDIs. Therefore, the purchasing of materials does not require procedures that differ from those mentioned in Chapter II, because this chapter took these into consideration. However, supplier selection should be emphasized briefly because of its particular importance.

4.133 The selection of reliable suppliers makes it easier to control inventories both in terms of delays and availability of materials. In fact, as will be developed further in this chapter, known delays allow to plan more accurately reorder points so as to have low inventories by the time materials ordered arrive. This corresponds to an outside contribution to materials management of specific organizations.

4.134 Whenever possible, the purchasing department should look for new interesting suppliers, particularly in areas where problems have been experienced in the past in respect to prices, delays or service. This search should also include suppliers of materials which are not frequently purchased, but are important for ROI operations.

4.135 The number of suppliers and many other market characteristics vary substantially, depending on the nature of the materials purchased. For instance, many chemicals are purchased overseas, while sand is available from a large number of local suppliers. This variety in materials makes it challenging to respond and sometimes to precede users needs.

4.141 Responsiveness to Users' Needs: Personnel charged with the responsibility of purchasing research materials frequently need to be more aware of the great importance attached by researchers to the availability of materials whenever these are required. As was mentioned for equipment, researchers often underestimate the total time required from the purchase requisition to the availability of what they have requested.

What portion of purchases do materials represent in your RDI?

Think about a key material. Is there one of the following areas which requires improvement?

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.142 Most materials should be available quite rapidly although personnel should take into consideration the point of origin of the materials ordered. Normal lead times are usually known by the purchasing department for most items. When longer lead times are expected, users should be informed.

4.143 It is not always possible for users to plan all their requirements well ahead. When some items have not been anticipated, it would appear that budgets should have special provisions for these unusual requests. This type of approach is very appreciated by users. It also demonstrates that RDI officials, although they are committed to better management of the RDI, are aware of the fundamental reason why the RDI exists in the first place.

4.144 Considering that many of the materials requested by users are taken from stock rather than directly ordered from the supplier, it is important to order based on accurate information.

4.211 Importance of Stock Records: Those RDIs which have systematic stock records place themselves at a considerable advantage vis-a-vis those that do not. Such records allow for better planning of quantities to be ordered and for proper control over valuable inventories. It should not be forgotten that inventories represent an investment which should be justified financially and tightly controlled.

4.212 Accurate stock records allow to know at all times the quantities and value of all items on hand, without having to actually count these items and to examine all invoices related to quantities in stock. Planning and control are thus easier at all times.

4.213 It is necessary to plan inventory levels and consumption patterns of materials in order to budget properly. When this information is not accurate or simply not available, it becomes difficult to have a high level of confidence in the budget figures for materials.
4.214 The consumption pattern of items used can be easily determined simply by looking at records. This examination could lead to substantial improvements in the ordering pattern if this step has not been already taken. The importance of determining the consumption pattern of materials will be obvious in the following section of this chapter.

4.215 Despite these advantages, fieldwork revealed that many RDIs did not have proper records. Some RDIs did not have any records whatsoever of the types, quantities and value of the stock on hand at any time.

4.216 In such circumstances, it is likely that orders were often placed for inappropriate quantities and with the wrong timing. When records exist but are poorly kept, the situation could be as bad, because decisions are taken based on the wrong information. Furthermore, resources are used inefficiently to update inaccurate records, which will not be trusted at all anymore at one point.

4.217 Generally-speaking, the state the stock records are in provides a good idea about the level of control over the operations of an RDI. For instance, poor records could indicate that purchases are made in a hurry—and likely at too high a cost, and that quantities received are not necessarily controlled. When an RDI gets into such a vicious circle, it takes somewhere to start the improvements from. Stock-records and related procedures could be such a place.

4.221 Content of Records and Control: The implementation of a stock record system requires that quantities and values on hand be known at that point in time, and that, procedures to update records be clear to all those involved. It should be noted that it takes much discipline to tightly control the update procedures to ensure stock record accurateness.

4.222 Items should be delivered to receiving, and not directly to the user department; otherwise, it is possible that the latter, being preoccupied more by the receiving of the items than by the

How would you describe the state of stock records in your RDI?

Why can this situation be considered a vicious circle?
updating of records, forgets to advise the person responsible for the stock records.

4.223 It is strongly recommended that storekeepers should not also be responsible for updating stock records. The purpose of the records is to control independently actual quantities, this control is greatly reduced when both operations are carried out in the same department.

4.224 Another control measure consists of having only one set of stock records, all kept in the same place (for manual records) and under the control of one individual responsible for their update (also for computerized records). This is applicable even if more than one store exists for the different types of materials.

4.225 Stock records should include at least the name of the item, the quantity on hand at the beginning of the period, detail of quantities received and of those issued, the dates of the transactions, and the ending balance after each transaction. It is strongly suggested that these records also include the name of the supplier, the invoice number, and the unit cost of the item, as this is the case in Figure 4.1.

Do you agree?

There are 9 characteristics mentioned. Which one(s) do you consider the most important? The least important?
4.226(a) Three well recognized methods exist for inventory valuation: FIFO (first in, first out), LIFO (last in, first out), and the weighted average cost. The first method assumes that the units issued to users are those which have been received first, among those units still in stock. The second method, LIFO, considers that quantities issued are those which have been received last.

4.226(b) The weighted average cost method values items all at the same cost; this cost is determined by the relative proportion of items acquired at different costs. For example, if 100 litres of oil are acquired at $3.10 and the next receipt is for 200 litres at $3.16, the weighted average cost will be $3.14. A more detailed problem is presented in Exercise 4.1.

Exercise 4.1: Comparison of the three cost methods

Situation:

There were 400 litres of a given acid on hand as of June 1. Unit cost per litre is $1.30. Another 200 litres was received on June 9, at a unit cost of $1.45, while usage was 250 litres. Usage was made of requisitions all made after June 10. What would be the inventory value at the end of June, according to each valuation method?

Do NOT read on unless you want to compare your solution with ours.

Solution:

(1) With FIFO, the 250 litres would have been issued at the cost of $1.30, because there was enough beginning inventory to cover this quantity. Accordingly, the value of the ending inventory would be:

\[(150 \text{ litres} @ $1.30) + (200 @ $1.45) = $485\]

(2) With LIFO, the first 200 units would have been issued at a cost of $1.45, and the last 50, at a cost of $1.30. Therefore, the ending inventory would be valued at:

\[350 \text{ litres} @ $1.30 = $455\]

(3) The weighted average cost method would yield an average cost of $1.35, obtained as follows:

\[
\frac{[(400 @ $1.30) + (200 @ $1.45)]}{600} = $1.35
\]

The ending inventory would then be:

\[350 \text{ litres} @ $1.35 = $472.50\]
4.227 It is not the accurateness of the computations which represents the major challenge, but rather, once again, the regular complete update of stock records.

4.228 Computers make the update task much easier and faster. However, it is not because information is computerized that its reliability should be taken for granted. It is indeed only the accurateness of computer computations which can be taken for granted; who knows if all receipts and issues have been posted?

4.231 Definition: Inventory stocktaking is a procedure which allows to count all items on hand at a specific date. Stocktaking makes possible the comparison between stock records and the types and quantities of all materials on hand. It is also intended to determine the value of goods which should be considered as assets at the financial year-end. This latter aspect will be discussed in section 4.6.

4.232 Inventory stocktaking should be a priority for all RDIs, but especially for those with a high inventory value or with potential problems in the reliability of stock records or inventory physical control. Both systems can provide control over the other one, as illustrated in Figure 4.2. In fact, there is no valid reason related to managerial considerations, which justifies not to take such an inventory at least once a year.

4.233 Stocktaking is performed at year-end in order to obtain an accurate figure in the financial statements of the RDI. By doing so, it is assumed that the control procedures over stocktaking are better than those over stock records. If this is not the case, it would be appropriate to consider the book value as the exact figure for the financial statements.

4.234 When stocktaking is taken at a date close to, but other than year-end, the quantities obtained must be adjusted to reflect the transactions between the stocktaking date and year-end.
Figure 4.2. Necessary Control Between Stock Records and Inventory Stocktaking

4.235(a) When discrepancies arise between quantities on hand and those as per records, they should be investigated, and the adjustments reflected in the records if necessary. It is often assumed that stocktaking is accurate, and records wrong, when there are discrepancies. This is not necessarily the case.

4.235(b) First, inventory count might be wrong. A double-count made by a different person is then appropriate. Secondly, a portion of the items might be in a location other than the store. In that case, it should be determined what that location is, and a count made. Thirdly, materials could have been counted, although they were received later than the last day accepted for materials to be included in the stock records (cut-off date).

4.235(c) Erroneous records might be caused mostly by a lack of adequate procedures, by insufficiently trained personnel, and by bypass of established procedures. These are aspects which might require measures such as a careful examination of the procedures, and more training for personnel.

4.235(d) In each of the instances mentioned in the last two paragraphs, efforts are required to improve the situation. It is not as much the correction of the error which is important, as the correction of the cause of that problem.

The third cause is the least obvious one for those unaccustomed to cut-off. Put a few figures below to try to determine the impact of including materials improperly as final inventories. What is the impact? Is the impact different if materials that should have been included, were not included? (Think about $Q_s + R - I = Q_f$)
4.241 Periodic Spot-checks: This procedure is similar to inventory stocktaking, with the difference that it is performed on an irregular basis and for a limited number of items. It is aimed at controlling quantities on hand and at comparing these with the stock records. Spot checks allow for control, including corrective measures, without the usual pressures present at year-end. What corrective measures should be taken?

4.242 Some RDIs have an internal audit section. This group should sometimes perform spot checks, among tasks they have to assume. This is particularly true for RDIs holding large stocks of either materials for use (e.g. fertilizers) or for sale (e.g. coffee and maize).

4.243 Periodic spot-checks by scientific personnel should be made for all chemicals and, other items likely to undergo degeneration or loss of purity or sensitivity. When applicable it is useful to place these items in such a way as to show clearly expiry dates.

4.244 Let us note in passing that, in most organizations, more and more emphasis is put on cycle counting. This procedure allows for counting at least once a year all items in stock. Important or expensive items could be counted up to once a month, unless records are nearly always accurate.

4.245 It could be useful to set a target for the accurateness of stock records. A level of 90% is often mentioned as a reasonable goal before any consideration is given to introduce more sophisticated systems than those already in place. Another target could be set for the total and individual value discrepancies between stock records and the actual values. For instance, no more than 5% of the items should have more than a 3% difference between the value as per the records, and the correct value. What is your estimate (or experience) of the accuracy level of the stock records in your RDI?

Would these objectives make sense in your RDI? Are they too difficult to reach or not close enough to what the exact figures should be?

4.311(a) Overall Considerations on Planning Quantities: This section is quite long, because it includes some of the most important, but least understood concepts in facilities and materials management. No effort has been saved to make the content pertinent but simple enough, considering the scope and breadth of the topic. It
should be emphasized that the reader must understand where each of the sub-sections fits within the whole picture, if he wants to learn as much as is intended from this section of the Manual. In order to do so, it is suggested to refer back as often as required to paragraph 4.311(b) and to all other paragraphs believed to be necessary.

4.311(b) Sub-sections 4.31 and 4.32 deal with overall planning considerations which give sense to the mathematical aspects of the following sections. Sub-section 4.33 helps to allocate efforts on the appropriate items in stock. Sub-sections 4.34 to 4.37 deal with quantities to order when demand for an item is independent from the demand for other items, and also with lead times and reorder points.

4.311(c) Sub-sections 4.38 and 4.39 cover ordering when demand is dependent (MRP), some computer considerations, and a Japanese approach named Just-in-Time (JIT). All these topics could be useful for managing RDIs more productively.

4.312 Some important activities might sometimes be delayed due to a stockout. Whether the item required but not on hand is expensive or not makes no difference to a user faced with having to delay his activities. Ideally, materials would arrive on time, where needed, and just in the right quantity; this conception would make inventories unnecessary. Although it seems impossible to attain, this approach is possible. However, few RDIs are in a context suitable to use exactly such an approach, although inventory reduction is an objective aimed for by most RDIs.

4.313 Inventories are usually justified by a desire to limit the number of orders due to ordering or transportation costs, by an effort to avoid stockouts caused by lead times, or by market conditions such as anticipated strikes by key suppliers or transporters.

4.314 It is obvious that proper and effective planning for future material requirements by department and for the whole RDI is an important area of activity for the productivity of each RDI.
4.315 It is particularly worth it to put efforts in planning for quantities when one or more of the following conditions is characteristic of the RDI:

- Limited efforts have been made in properly managing materials;
- Materials represent an important element of the RDI budget;
- There are many arbitrary rules presently used for ordering;
- Some costly or important materials are causing problems such as stockouts.

4.316 There is a misconception that it is preferable to hold more stock than less, although more stock does not imply that the appropriate items are on hand. In some cases, stockouts can become such a frightful idea, that excessive inventories will be on hand at all times. It is interesting to note that managers of most organizations are more “penalized” for stockouts than for excessive stocks. There is no reason to believe that RDIs differ on that respect.

4.317 It is likely that at one point or another top RDI officials will ask to reduce inventories by a given percentage, say 20%. Such a reduction is seldom made on the proper items, because it is often made by means as arbitrary as the 20% cut decided. In fact, it is even possible that the present inventory level is reasonable, considering the RDI characteristics.

4.318 Overall, planning for materials is much easier when there are clear objectives for the RDI, and when the RDI activities for the coming year have been clearly established.

4.321 Annual Planning of Quantities: Fieldwork researchers found that planning for materials requirements for the following financial year constituted a common problem with RDIs. In some countries, planning for quantities is important not only for budgeting internally, but also because all budgets should be forwarded to the “National Supreme Planning Council” or to a similar group.

Which of these characteristics apply to your RDI?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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</thead>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What do you conclude in terms of efforts to be done?

Is it the case in your RDI? How is it possible to know it?
4.322 Virements of funds between budget items can sometimes be so laborious that attempts to do so are not often made. Consequently, it is even more important that previsions regarding quantities and types of items required be quite accurate. However, there is a danger of overstatement of the quantities originally determined, especially if it is common for top RDI officials and for the Planning Council to reduce quantities asked for by an arbitrary percentage.

4.323 It should be recognized that it is impossible to determine accurately quantities for all materials likely to be used, although planned activities have been agreed upon. Budgets are estimates, despite the fact that these figures are sometimes taken for precise. If too much time is spent on trying to plan for minor items, less efforts will be devoted to the fundamental activities of the RDI. In fact, researchers have neither the training nor the interest for this type of exercise, particularly when the requirements have to be stated in financial terms.

4.324 The regular budget procedure consists to ask users to provide a figure for the expected requirements in their department. All departmental budgets are then added to obtain a total for the RDI. Obviously, this procedure does not make much sense if quantities have been planned based mostly on current year’s requirements, rather than on next year’s objectives. Quantities mentioned should not be simply taken for granted: they should be discussed to validate their significance.

4.325 The timing of the quantities planned is important, because the budget could be influenced substantially. For instance, if important funds are required toward the end of the financial year, the impact is different from when they are required right at the beginning of the year.

4.326 As can be seen from the previous discussion, impressions and rough estimates are not sufficient to plan quantities. Some methods are required to improve aspects such as the determination of reorder points. Improved planning also means a better chance for the purchasing department to plan users’ requirements and to respond to their needs more rapidly.
4.327 Where to begin? Efforts should be made particularly on expensive materials and on those representing the largest portion of expenditures. These materials are the ones for which proper methods can mean the most both in financial and operational terms.

4.331 ABC Method of Resources Allocation:
The ABC method is based on the Pareto law (20–80 rule) discussed in the preceding chapter. For materials, it is a technique used in the determination of the 20% of items that represent approximately 80% of the value of items used in a store or in the entire RDI. The group of about 20% is called the A group. The B group comprises the following 30% of the items, representing about 15% of the value. The last group is the C group and corresponds to 50% of the items, worth only 5% of the total value of items used.

4.332 There are four steps in the ABC method:
(1) Determine the utilization values, based on previous year data;
(2) Classify items in descending order;
(3) Compute percentages in terms of utilization and number;
(4) Determine the 3 groups: A, B, and C.

It is as simple as ABC, as illustrated in the following exercise, Exercise 4.2, for which the solution is also represented graphically in Figure 4.3.

Exercise 4.2: The ABC method of resource allocation

[Instructor(s): This exercise could well be assigned as an evening “homework”. It is not difficult, but it could require too much time during the class if it has not been done previously.]

Situation:
A large meteorological centre uses a variety of items, including the following ones picked at random to see how the ABC method works. You are asked to perform an ABC type of analysis.

<table>
<thead>
<tr>
<th>Item number</th>
<th>Quantity used</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item number</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>435</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>244.18</td>
<td>3.76</td>
<td>15.98</td>
</tr>
<tr>
<td>46</td>
<td>68</td>
<td>70</td>
</tr>
<tr>
<td>Item number</td>
<td>1,000</td>
<td>1,645</td>
</tr>
<tr>
<td>3.76</td>
<td>1.00</td>
<td>0.47</td>
</tr>
</tbody>
</table>

The best way to be convinced about the applicability of this method for inventories is to take 20 items at random from the stock records of your RDI, and to classify these items according to the ABC method. You will never forget the results!
(Exercise 4.2: Continued)

Solution:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit cost</th>
<th>Annual value of utilization (3) = (1) x (2)</th>
<th>Cumulative Utilization (4)</th>
<th>Cumulative % of utiliz. (4)/234998</th>
<th>Cumulative % of units (1)/7900</th>
</tr>
</thead>
<tbody>
<tr>
<td>A items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>435</td>
<td>244.18</td>
<td>$106,218</td>
<td>$106,218</td>
<td>45.2%</td>
<td>5.5%</td>
</tr>
<tr>
<td>45</td>
<td>235</td>
<td>313.00</td>
<td>73,555</td>
<td>179,773</td>
<td>76.5%</td>
<td>8.5%</td>
</tr>
<tr>
<td>B items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>485</td>
<td>47.00</td>
<td>22,795</td>
<td>202,568</td>
<td>86.2%</td>
<td>14.6%</td>
</tr>
<tr>
<td>81</td>
<td>600</td>
<td>18.80</td>
<td>11,280</td>
<td>213,848</td>
<td>91.0%</td>
<td>22.2%</td>
</tr>
<tr>
<td>27</td>
<td>500</td>
<td>15.98</td>
<td>7,990</td>
<td>221,838</td>
<td>94.4%</td>
<td>28.5%</td>
</tr>
<tr>
<td>C items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>500</td>
<td>9.87</td>
<td>4,935</td>
<td>226,773</td>
<td>96.5%</td>
<td>34.9%</td>
</tr>
<tr>
<td>46</td>
<td>1,000</td>
<td>3.76</td>
<td>3,760</td>
<td>230,533</td>
<td>98.1%</td>
<td>47.5%</td>
</tr>
<tr>
<td>13</td>
<td>500</td>
<td>3.76</td>
<td>1,880</td>
<td>232,413</td>
<td>98.9%</td>
<td>53.9%</td>
</tr>
<tr>
<td>68</td>
<td>1,645</td>
<td>1.00</td>
<td>1,645</td>
<td>234,058</td>
<td>99.6%</td>
<td>74.7%</td>
</tr>
<tr>
<td>70</td>
<td>2,000</td>
<td>0.47</td>
<td>940</td>
<td>234,998</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

7,900 units $ 234,998

Figure 4.3. An ABC Representation Based on Data in Exercise 4.2

4.333 The A items should be the ones for which most planning and controlling efforts are done. This observation implies that, for instance, it is time now to compute reorder points properly for these items. The impact of ordering the right
quantities for C items is much smaller than it is for A items. In this sense, resource allocation is made where the payoffs appear to be better.

4.341(a) Definition: The economic order quantity (EOQ) is a formula which determines the optimal quantity to order, considering ordering costs and inventory holding costs. It takes only these 2 costs into consideration, not transportation or stockout costs.

4.341(b) The right quantity to order represents a tradeoff between on the one hand, ordering often and incurring low inventory holding costs, and on the other hand, ordering less often with the consequence that inventories are higher. Example 4.3 —coming in a few pages —provides the details on the computation of the EOQ.

4.341(c) The EOQ formula can be used in a context of independent demand, e.g. when it is necessary to estimate the overall quantity needed in order to determine the quantity to be ordered. For instance, the number of tyres to be changed due to blow outs represents an independent demand.

4.341(d) A dependent demand is a quantity which is directly determined by another quantity. For example, the number of tyres to be changed because of preventive maintenance and the timing of these changes incidentally, is known as soon as the schedule for preventive maintenance is determined. The number can indeed be planned accurately, although there could be adjustments if the schedule and the type of operations performed is modified. A method called MRP is used for dependent demand. It is developed later in this section.

4.341(e) The distinction between independent and dependent demand is fundamental in the determination of the proper quantity ordering method to use. A look at Figure 4.4 might help to remember this distinction.

4.342(a) There are important hypotheses applicable to EOQ. The most restrictive one for RDIs is that overall demand for an item is known and constant. Few situations, if any, fit perfectly this situation. Some argue that this reason in itself is sufficient to ignore the whole concept of EOQ.
4.342(b) We disagree. It is not as much the exact quantity to order which is important, as to have a useful model for situations where the demand for an item shows an acceptable variation from average over a period of time. What is particularly important of EOQ is the effort to reach an equilibrium between ordering costs and holding costs. The most important lesson from EOQ for the readers of this manual is to aim for a zone around this equilibrium.

4.342(c) It is surprising how much ordering and holding costs represent in most organizations. In fact, they are quite often 50% higher than originally expected. The determination of such figures could influence significantly quantities ordered for most items used in many RDIs.

4.343(a) Definition: Inventory holding costs correspond to all costs directly identifiable to the decision to hold inventories. They include insurance, obsolescence, theft, storekeepers' salaries, stores repairs and maintenance, and cost of capital used (opportunity cost).

4.343(b) Opportunity costs correspond to alternative uses of funds. For instance, if less funds would be tied up in inventories, they could be used for purposes such as building an extension to the existing premises. Naturally, this type of alternative use of funds could be difficult if funding agencies do not provide as much funding.
to those RDIs which manage their resources better, such as by reducing inventories.

4.343(c) Annual inventory holding costs often run over 35% of acquisition costs (cost of purchase)! This is a surprising observation at first glance. However, a close examination of such costs should reveal that it costs to some RDIs over 40%—and even 45%—of original costs to hold inventories for one year. For instance, the more space problems there are, the more expensive storage is, considering that less space implies more handling and all other problems related to overcrowded facilities.

4.343(d) The reduction of inventories represents a tremendous opportunity to improve the efficient management of rare resources. For instance, consider how much savings would be realized by an RDI in which a concerted effort by all members of personnel would make possible a permanent reduction of inventories of $100,000. If the inventory holding cost is 40% in that RDI, then a saving of $40,000 would be realized. This saving corresponds to an annual additional financing of $40,000!

4.344(a) **Definition: Ordering costs** correspond to all costs which are identifiable to placing an order. They include such costs as those for the preparation of requisitions and purchase orders (mostly salaries and paperwork), postage, handling costs including receiving, and clearing of suppliers invoices for final payment. The larger the quantity ordered, the smaller the number of orders is. Therefore, ordering costs should decrease accordingly.

4.344(b) Although it can be argued that salaries of personnel are a fixed expense, it should be recognized that individuals can perform a variety of tasks. If this is actually the case, it implies that individuals can be transferred from one department to another, making it possible for savings in ordering costs to become actual.

4.345(a) As can be deduced from the costs included in ordering costs, salaries constitute a large percentage of ordering costs. When the cost
of salaries is considered relatively low in comparison with the type of costs included in inventory holding costs, it is advantageous to order more often.

4.345(b) More orders imply higher ordering costs, but smaller holding (carrying) costs. Indeed, a smaller quantity is ordered every time, resulting in lower inventories. Thus, there is a tradeoff, resulting in an inverse relationship, between both types of costs: If one goes up, the other goes down.

4.345(c) As will be seen in the figure included in the example, there is a minimum point for the total cost curve. Once again, it is not this point which is of interest, but the zone which surrounds it. This zone corresponds to slightly higher costs, but is more likely to include the actual quantity ordered for an item. As can be deduced from the figure on EOQ, Example 4.3 demonstrates that there are indeed limited additional costs to operate in such a zone.

Example 4.3: The determination of ordering and carrying costs

[Instructor(s): The type of reasoning on which EOQ and other similar types of equilibrium points are based is not necessarily easy to understand for all participants. It is suggested to spend enough time on the logics of this approach, rather than on the computational details.]

Situation:

A medical research centre uses hormone doses regularly, and in quantities reasonably close to constant consumption. Annual consumption is 2,000 doses. It costs $10 to order, while the annual carrying cost has been established at $2.50. The purchase price is $8.00.

1. Determine the economic order quantity iteratively, by computing holding costs and ordering costs if quantities of 50, 100, 110, 120, 125, 126, 127, 128, 129, 130, 140, 150, and 200 were ordered.
2. Compute the EOQ using the EOQ formula.
3. What would be the impact on total cost of ordering 20% more or 20% less than this optimal quantity?

Do NOT read on unless you want to compare your solution with ours.
(Example 4.3: Continued)

Solution:

1. Iteratively, the computation of the economic order point requires to determine the carrying cost and the ordering cost for each quantity which can be ordered, and to determine the quantity for which the total cost is the lowest.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Carrying cost($)</th>
<th>Ordering cost($)</th>
<th>Total cost($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>62.50*</td>
<td>400.00**</td>
<td>462.50</td>
</tr>
<tr>
<td>100</td>
<td>125.00</td>
<td>200.00</td>
<td>325.00</td>
</tr>
<tr>
<td>110</td>
<td>137.50</td>
<td>181.81</td>
<td>319.31</td>
</tr>
<tr>
<td>120</td>
<td>150.00</td>
<td>166.66</td>
<td>316.66</td>
</tr>
<tr>
<td>125</td>
<td>156.25</td>
<td>160.00</td>
<td>316.25</td>
</tr>
<tr>
<td>126</td>
<td>157.50</td>
<td>158.73</td>
<td>316.23***</td>
</tr>
<tr>
<td>127</td>
<td>158.75</td>
<td>157.48</td>
<td>316.23***</td>
</tr>
<tr>
<td>128</td>
<td>160.00</td>
<td>156.25</td>
<td>316.25</td>
</tr>
<tr>
<td>129</td>
<td>161.25</td>
<td>155.04</td>
<td>316.29</td>
</tr>
<tr>
<td>130</td>
<td>162.50</td>
<td>153.85</td>
<td>316.35</td>
</tr>
<tr>
<td>140</td>
<td>175.00</td>
<td>142.86</td>
<td>317.86</td>
</tr>
<tr>
<td>150</td>
<td>187.50</td>
<td>133.33</td>
<td>320.83</td>
</tr>
<tr>
<td>200</td>
<td>250.00</td>
<td>100.00</td>
<td>350.00</td>
</tr>
</tbody>
</table>

* [(50/2) x $2.50] = $62.50
** [(2,000/50) x $10] = $400.00
*** The lowest cost corresponds to quantities of 126 and 127.

The costs above are illustrated by Figure 4.5.

2. According to the EOQ formula, the optimal ordering quantity is:

\[
\sqrt{\frac{2 \times 2,000 \times 10}{2.50}} = 126.5 \text{ doses every order.}
\]

Therefore, quantities of 126 and 127 would be optimal. Let’s take 127.

The carrying cost for average inventory would be

\[
(127/2) \times $2.50 = $158.75
\]

and the ordering cost,

\[
(2,000 / 127) \times $10 = $157.48
\]

In total, both types of costs amount to $316.23.

3. Ordering 80% of 127 doses = 102 doses, while ordering 120% of 127 doses = 152 doses. The costs would be the following:

<table>
<thead>
<tr>
<th></th>
<th>102</th>
<th>152</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering costs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[(2,000 / 102) x $10]</td>
<td>$196.07</td>
<td></td>
</tr>
<tr>
<td>[2,000 / 152] x $10</td>
<td>$131.58</td>
<td></td>
</tr>
<tr>
<td>Carrying costs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[(102 / 2) x $2.50]</td>
<td>127.50</td>
<td></td>
</tr>
<tr>
<td>[(152 / 2) x $2.50]</td>
<td>190.00</td>
<td></td>
</tr>
<tr>
<td>Total costs for both types:</td>
<td>$323.57</td>
<td>$321.58</td>
</tr>
</tbody>
</table>

The cost difference with the costs for the optimal quantity are less than 3% in both cases, although the quantities ordered are 20% less and 20% more.
Figure 4.5. Determination of the Economic Order Quantity (EOQ) Using Data of Example 4.3

4.345(d) The iterative process to determine the optimal quantity to order is tedious, as could be seen in question (1) of Example 4.3. The following formula allows to make this computation rapidly, as it has been shown in question (2) of the example:

\[ \text{EOQ} = \left(\frac{2 \times D \times OC}{HC}\right)^{1/2} \]

where:
- \( D \) = annual demand in units for 1 type of item
- \( OC \) = ordering cost for 1 order
- \( HC \) = holding cost in % of acquisition cost
- \( ^{1/2} \) = square root of the quantity between [ ].

4.345(e) This formula can be useful if there is a relatively stable and constant independent demand. Appropriate efforts should be made in the determination of the three variables, e.g. demand, ordering costs and holding costs. It is interesting to know that a 20% overstatement or understatement of any or all of these figures will usually result in no more than a 5% difference with the optimal cost. Hopefully, most RDIs should be able to determine the values of the three variables within a 20% range.

4.345(f) The exercise is worth it when it is expected that important savings are possible, due to the modifications to quantities ordered when EOQs will be adopted instead of mostly arbitrary...
quantities. However, the three variables do not keep the same values over time (are not these variables?), and it is necessary to determine their new value when it is believed that major changes in value have taken place.

4.346(a) The EOQ formula is a good starting point for reasoning inventory-related costs. It provides an answer to the question "What quantity should be ordered?". This answer may be used as a guideline, because other factors than those already mentioned are likely to be considered also.

4.346(b) For instance, when a number of different items are ordered from one supplier, it is unlikely that orders will be placed only for items due to be ordered on that specific date or for the exact quantities as per EOQ.

4.347(a) Quantity discounts represent another factor which can modify the quantity ordered following computations obtained through EOQ. When suppliers offer such discounts, it is a good idea to determine if there are financial benefits for the RDI.

4.347(b) Discounts usually imply that a larger quantity than the one determined through EOQ should be considered. The impact is always the same: economies due to discounts and to larger quantities ordered — resulting in fewer orders — as compared to higher holding costs. It is only when additional holding costs are more than offset by the other two economies that ordering in a quantity larger than EOQ is justified financially. Exercise 4.4 represents a typical situation for RDIs.

Exercise 4.4: Quantity discounts

Situation:

The medical RDI mentioned in Example 4.3 is being offered a 10% discount for buying doses in quantities of 150 or more per order. Is it advantageous to order 150 doses at a time?

Do NOT read on unless you want to compare your answer with ours.
(Exercise 4.4: Continued)

Solution:

Although carrying costs will be higher, ordering costs and the 10% discount could compensate for these additional carrying costs.

Ordering 150 doses costs

\[
\left(\frac{150}{2}\right) \times 2.50 = 187.50 \text{ in carrying costs, but only}
\]

\[
(2,000 / 150) \times 10 = 133.33 \text{ in ordering costs, for a total of}
\]

\[
320.83, \text{ before the 10% discount on the total purchasing cost.}
\]

This saving is equal to:

\[
(150 \times 8) \times 10\% = 120.00,
\]

resulting in a net cost — other than for purchase price — of $200.83. This amount is substantially smaller than the $316.23 paid annually for the carrying and ordering costs for the EOQ of 127 doses.

Therefore, the RDI should order hormone doses in quantities of 150 units at a time.

4.347(c) Many RDIs are seriously constrained for available space and money. Therefore, it might not be wise to buy a quantity which would last for 3 years, despite the fact that it appears to be a sound financial investment.

4.347(d) Although it is sometimes difficult to do otherwise, it is a very shortsighted view to order in quantities much smaller than those according to EOQ. A second examination of the figures in the above example on the iterative approach to EOQ should prove convincing. In fact, the same total quantity of items as before is required, even when quantities ordered are smaller. High ordering costs will be incurred, resulting in a higher total cost than before, even when an interval of time of only six months— and sometimes less—is considered.

4.348(a) Users prefer to have a quantity on hand such as there will be no stockout. In fact, they are directly penalized when a stockout occurs, while it is mostly the RDI as a whole which is penalized by excessive inventories.

4.348(b) Efforts should be made to determine the impact of a stockout on the operations of the RDI. Obviously, some stockouts have more serious consequences than others. Some of these

How does this observation illustrate the systems approach?
consequences can be evaluated financially. For instance, this is the case of lost time and of expediting costs necessary to accelerate the arrival of the items expected.

4.348(c) If it is determined that no stockout can be incurred for most of the expensive items, then it might be difficult to reduce substantially the cost of inventories. However, if a proper analysis reveals that it makes sense to incur some stockouts for less expensive items, it is likely that smaller quantities on hand than before are necessary, resulting in more available space.

4.351 Definition: Lead time represents the period from a user's requisition to the satisfaction of the need. When requisitions and purchase orders are processed rapidly, and to local suppliers, lead times are small. Therefore, the consequence of stockouts is not as important as for situations which imply long lead times, such as the ordering overseas of many of the chemicals.

4.352 When suppliers hold items for "immediate" delivery, this represents an opportunity to use suppliers as additional stores for RDIs, particularly when these are local suppliers. As a consequence, smaller stores are necessary (see Figure 4.6) than what would be the case otherwise, because suppliers store a larger quantity of items (represented by a larger rectangle on Figure 4.6). It should be ensured that suppliers do not act the same way with manufacturers, otherwise key items will have longer lead times than initially expected.

What are the longest lead times for materials ordered by your RDI? Do you think that these lead times are mostly due to:

Your answer

(1) A poor supplier selection?
(2) The type of material?
(3) Distance?
(4) Transportation problems?
(5) Others?

Figure 4.6. Impact of Larger Quantities Held by Suppliers, on Quantities Held in Stores
4.353 Internal lead times should not be neglected. For instance, if researchers wait too long to order items which are not kept in stock, the purchasing department might have to limit its search for the best supplier (when applicable), and select a faster and more expensive mode of delivery than usual. Once in a while, it is possible to accelerate purchasing steps, including paperwork. But this approach should not be used often, because it is costly and does not allow purchasing to do a good job.

4.354 Suppliers' reliability is important because computation of lead times often takes into consideration the longest delay. Therefore, it might be preferable to have a supplier delivering steadily two weeks after an order is placed, than one with deliveries taking anywhere between one and three weeks.

4.355 A close monitoring of lead times usually reveals that it is possible to reduce them by improving procedures and by planning better the type of items and the quantities required. The reduction of lead times reduces reorder points.

4.361 Safety Stocks and Reorder Points: It was determined during fieldwork that practically no RDI including those RDIs with computer facilities, had a systematic reorder system or a method to determine optimum reorder quantities. This is a surprising finding, because a systematic reorder system makes it easier to determine rapidly what, when and how much to order. It saves time and money, once it is correctly in place. As discussed in the subsection on the ABC method, it can be started by integrating only the most important materials, because these are the ones which represent potential savings.

4.362 Definition: Safety stocks are additional quantities that are in stock to protect against stockouts. If demand and lead times were constant, no safety stock would be required because there would be no uncertainty regarding consumption and delivery patterns. However, this is seldom the case.
The more important the variability of consumption and delivery, the higher the safety stocks required to compensate this uncertainty. The desired service level also influences the safety stock level.

Definition: A service level is the percentage of demand that is satisfied within a specified time. For example, there could be an objective of 95% of the requisitions being processed. The higher the service level, the higher the safety stock. A 95% service level usually requires many more items continuously on hand than a 50% service level. At the limit, a 0% service level is possible: this implies that no requisition would be processed within 24 hours. The same reasoning as for requisitions applies to stock, as can be seen on Figure 4.7.

Figure 4.7. Key Factors Influencing Stores Safety Stock Level

Provide 2 examples of service levels which could be (or are) measured in your organization.

What factors could justify a low service level?

The statistical aspects of the determination of safety stocks can be quite demanding for those readers without an appropriate statistical background. However, a simple statistical example is provided in Example 4.5. The reasoning is fundamentally the same for more complex situations.
Example 4.5: Determination of a reorder stock corresponding to a desired service level

[Instructor(s): The reasoning of lead times, service level, reorder points, fixed quantity, and fixed interval could be difficult for many participants if they do not understand primarily the logics of reordering systems. It is worth it to spend the necessary efforts on this issue, because it constitutes a major problem for many RDIs. Once again, it is logics which should come first and should be stressed to participants, not computations.]

Situation:

Demand for special flashlight batteries varies weekly from 1 to 4 batteries. In fact, demand follows the following distribution:

- 15% of the times, demand is only 1 battery;
- 30% of the times, demand is 2 batteries;
- 3 batteries are required 35% of the times;
- 4 batteries are required for the remaining 20%.

It takes 1 week for these special batteries to be delivered. How many batteries should there be in stock when a new order is placed with the supplier, considering that an 80% service level is aimed for?

Solution:

An order should be placed whenever there are 3 batteries left in stock. It is indeed at this level that demand will be satisfied 80% of the times, considering that it takes exactly 1 week for the order to be delivered. However, it should be expected that there will be a stockout 20% of the times, because weekly demand is 4 batteries in 20% of the instances.

4.366 Definition: A reorder point is a quantity of items on hand which, when it is reached, signals that it is necessary to place an order for a pre-specified quantity, so that the service level already determined be adhered to.

4.367 Reorder points and safety stocks can be computed with any significance only if reliable data is available. If it is not the case, it is suggested that reliable stock records be implemented before too many resources be spent on computing safety stocks. As an alternative approach, it is possible to base reorder points on anticipated consumption and lead times, as long as efforts are also immediately made to improve records. However, such an approach is risky, because it is based on estimates with no solid basis to support them. Many stockouts and excess quantities could still coexist, although for different items.

RELIABLE data are what make inventory methods significant. How would you evaluate the state of the stock records in your RDI? (Circle your answer).

<table>
<thead>
<tr>
<th>Poor</th>
<th>Fair</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
4.371 **Fixed-order quantity or fixed period?**
The first approach consists in ordering a quantity equal to EOQ, when the reorder point is reached. The second method is based on ordering, at fixed intervals, a sufficient quantity to reach a pre-specified service level.

4.372 The fixed-order quantity method deals with the uncertainty of demand by placing an order whenever the reorder point is reached. This situation is illustrated in Figure 4.8. The time it takes to reach this level could vary, without any impact on the quantity to be ordered and on the timing of the order.

Figure 4.8. Fixed-Order Quantity Model

4.373 The double-bin method constitutes a simple practical approach to the fixed-order quantity model. It consists in separating the quantity used once the order will have been placed from the quantity used before the reorder point is reached. If the separation is physical, a quantity sufficient to reach the reorder point is put on one bin. When this quantity is exhausted, storekeepers go to the second bin, where a quantity sufficient to face demand until the quantity from the next order is received. Before they take a single item, they send the reorder requisition form on top of the corresponding recipient on the second bin, to the purchasing department.

Before going any further, make sure that you understand the relationship between safety stocks, service level and reorder point. For instance, what is the impact of an increase in the service level?

What do you think of this method?
4.374 The fixed interval method is most appropriate when orders are placed regularly with suppliers. When appropriate, the interval is computed so as to make possible orders for quantities about equal to EOQ.

4.375 The quantity to order is computed as follows:

\[ Q = DA - S - EO \]

where:

\[ Q \] = Quantity to be ordered

\[ DA \] = Demand to be satisfied (service level of ...%) until next quantity ordered arrives

\[ S \] = Stock (Inventory on hand)

\[ EO \] = Expected orders (items already ordered, but not yet arrived)

The following example, Example 4.6, illustrates the fixed interval method.

Example 4.6: Determination of the quantity to order when using the fixed interval method

Situation:

An RDI uses between 90 and 110 specimens monthly for biological experiments. Orders are placed on the first working day of each month and always arrive during the last week of the month. How many specimens should be ordered, considering that 110 are on hand now?

Solution:

If it is important to have no stockout, then the ordering process should ensure that 110 specimens will be on hand at the beginning of each month. If demand is for less than that number, then an adjustment will be made when the next order is placed.

This is the way that the formula \[ Q = DA - S - EO \] works. Demand could be as high as 110 this month, which would reduce the present inventory to 0. Therefore, it is necessary to order 110 specimens, as evidenced by the formula:

\[ Q = (110 \times 2 \text{ months}^*) - 110 - 0 = 110 \text{ units}. \]

If ever demand is say 95, then the ending inventory will be:

\[ (110 - 95) + 110 = 125, \]

a quantity which would make it possible to order only 95 specimens in the following period.

\* = It should be considered that no order other than the one to be decided will arrive before close to 2 months. Consequently, if the service level is to be 100%, there is no risk of stockout, and a demand of 110 should always be planned for.
4.381 Materials Requirements Planning: This approach is used mostly when there is a dependent demand. It aims at ordering the right quantity at the right time, an important consideration when demand is unstable. In fact, MRP logics helps to plan the exact week (or date) on which an order should be placed, so as to receive the items on time, considering lead times applicable to each item.

4.382 The computational aspects of MRP can be tedious. Those RDIs with computers can use software packages available for microcomputers and for other sizes of systems also. In the latter case, the package is more sophisticated. It is interesting to note that the basic computations of MRP are easy enough that a simple situation can be programmed on an electronic spreadsheet within a few hours.

4.383 An application of the MRP approach follows. When looking at Example 4.7, consider how easy it is to adjust any quantity or lead time. For those RDIs with computer facilities, it is even possible to use simulation or packages which make it possible to integrate materials requirements planning with financial planning and with purchasing.

Example 4.7: Using an MRP situation

Situation:

An RDI is performing research on sisal. Quantities required vary with the type of experiment made. A quantity is estimated for each experiment, received at the time it is required, and used in whole or in part. There are sometimes products already tested which might be used for other tests and which are then considered as inventories on hand for that specific experiment.

There are presently 2 experiments planned with sisal. The information is as follows:

<table>
<thead>
<tr>
<th>Quant. required (week 7)</th>
<th>Experiment #112</th>
<th>Experiment #113</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 modified bales</td>
<td>12 modified bales</td>
<td></td>
</tr>
<tr>
<td>12 modified bales</td>
<td>15 modified bales</td>
<td></td>
</tr>
<tr>
<td>4 modified bales</td>
<td>5 modified bales</td>
<td></td>
</tr>
</tbody>
</table>

| Number of sisal bales to make 1 modified bale | 2 bales | 3 bales |
| Lead time to receive sisal order | 2 weeks for both experiments |
| Quantity of sisal bales in inventory | 15 bales, which can be used for both |

When is it necessary to order sisal bales and in what quantity should it be ordered?

(Example 4.7 is continued on the next page)
Solution:

<table>
<thead>
<tr>
<th>Line#</th>
<th>Description of the step</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Experiment #112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Gross requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>On hand</td>
<td>(4)</td>
<td>(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Net requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Experiment #113</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Gross requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>On hand</td>
<td>(5)</td>
<td>(5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Net requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Sisal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Gross requirements:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2 bales each for line 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3 bales each for line 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Total gross requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>On hand</td>
<td>(15)</td>
<td>(15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Net requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Order release</td>
<td>18</td>
<td>69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Therefore, 18 bales of sisal should be ordered in week 5, and 69 bales in week 6.

Try MRP by using an appropriate example for your RDI (even if you are not sure about lead times).

4.384 As can be observed in the example, the MRP method determines the required quantities in a very systematic way. It takes into consideration quantities on hand, before carrying the net quantity required to the proper period where it should be ordered. In the example, orders are placed only for the exact quantities required, according to a method called "lot-for-lot". However, there are many more ordering methods used in MRP. Interested persons may read any operations management textbook, or go to the source book on MRP, a text written by Orlicky.

4.385 An MRP system requires four inputs: a master schedule, bills of materials — lists of all components and raw materials included in a
finished product or in an activity — quantities on hand, and lead times. The usual outputs are the dates when to order and the quantities to order. Although MRP can be used in service organizations, it is mostly used in businesses manufacturing goods.

4.386 For most RDI officials and other persons concerned by the planning of quantities, the most important lesson to remember from MRP is its systematic approach to determine the dates and quantities. However, it should be noted that even a computerized system still requires proper inputs determined, at least initially, by individuals.

4.391 Definition: Just-in-time (JIT) is a philosophy aimed at substantially reducing inventories by ordering only small quantities of items so that they arrive only at the moment they are required. This approach originates from Japan and it has had an impact on numerous organizations worldwide. It is believed that this philosophy can be useful to RDIs although some of its components are mostly appropriate where production is relatively standardized.

Have you heard or read about this approach before reading it in this Manual?

4.392 The JIT approach requires a very close association with suppliers. It is important that they be kept aware of the expected needs of the buying organization, in order for them to respond rapidly to needs confirmed through purchase orders. As can be deduced, this type of relationship can be used mostly with local suppliers who are dedicated to satisfying the buyer's needs very rapidly. Just-in-time should not be discarded without examining some other implications also.

Does your RDI have such suppliers for some of its key materials?

4.393 An objective such as zero-stock through close relationships with suppliers is not attainable by RDIs. However, the concept of ordering much more often could be interesting, particularly for those overcrowded RDIs with a lack of storage space. If inventories are costly, they should be reduced.

4.394 Simultaneously, all steps should be taken to reduce ordering costs. For instance, phone calls should be sufficient to order many of the items bought from local suppliers, as long as proper
written arrangements have been taken accordingly. This could allow to receive small quantities, while incurring smaller ordering costs. As conceptually represented in Figure 4.9, this situation is advantageous from both sides! Exercise 4.8 allows the reader to check it by himself and to visualize it in Figure 4.10.

Figure 4.9. Impact of a Reduction in Ordering Costs on Carrying Costs

Exercise 4.8: Reduction of order size due to a reduction in ordering costs

Situation:

Due to important efforts made to reduce ordering costs, an RDI has succeeded in doing so for local orders. Ordering costs have declined by 75%; they are now estimated to be at 4 times less than they were before. What is the impact on the economic order quantity (EOQ) for the items purchased locally?

Do NOT read on unless you want to compare your answer with ours.

Solution:

There are no carrying or ordering costs mentioned above. There is no demand either. This is caused by the fact that the impact is the same on all local orders: it reduces all EOQs by 50%. In fact, try any figures where you will modify only the unitary ordering cost by reducing it by 75%, and you will reach the same conclusion.

(Exercise 4.8 is continued on the next page)
(Exercise 4.8: Continued)

For instance, if we take the example of the RDI where hormone doses were ordered (Example 4.3):

According to the EOQ formula, the optimal ordering quantity was:

$$\sqrt{\frac{2 \times 2,000 \times 10}{2.50}} = 127$$

where demand was 2,000 doses per year,
ordering cost was $10 and carrying costs was $2.50.

Now, let’s reduce the ordering cost by 75%; it is now $2.50. The EOQ becomes:

$$\sqrt{\frac{2 \times 2,000 \times 2.50}{2.50}} = 63$$

which is half the quantity previously ordered.

The cost of an order of 127 doses was

$$\left(\frac{127}{2}\right) \times 2.50 = 158.75$$

for the carrying cost for average inventory, and

$$\left(\frac{2,000}{127}\right) \times 10 = 157.48$$

for annual ordering costs. In total, both types of costs amount to $316.23.

What is the impact on total carrying and ordering costs, when the EOQ becomes 63 doses rather than 127? They are also reduced by 50%. We will let the reader prove it for himself.

Figure 4.10. Impact of a Reduction of Ordering Cost by a Factor of 4 on the Quantity Ordered

Physical Control: Records are helpful to control quantities and value of inventories. Physical control procedures are aimed at protecting people from dangerous items, and objects from being stolen or misused.

Inventory control is often considered to be applicable only to materials, but it is not the case. Although many RDIs do not have as much
work-in-process and finished goods inventories as companies producing goods, some do. For instance, control of seedlings of coffee that will be sold is important, particularly when considering that coffee represents a major source of revenue for this type of RDI.

4.422 Similarly, appropriate control measures of biological specimens should be determined and enforced. The escape of such specimens may create environmental hazards, including potential diseases if tests being performed are dangerous. The fact that some experiments could have to be started all over again should also be considered.

4.431 Materials do not represent only a bunch of items. They are identifiable, valuable and controllable. In fact, the greater the value of materials to be protected — both for intended and unintended users — the more efforts should be made to control these materials adequately. However, the physical control over these should not be more costly than their value.

4.432 It was noted during fieldwork that security of storage areas for materials was a problem. In a number of instances, laboratory heads had custody of, and obviously access to, the same materials. As a consequence, nobody was really responsible for the stock held in those storage areas.

4.441 Appropriate measures such as the issue to a few authorized users, should be taken particularly for dangerous materials. Safety rules regarding this type of materials must be known and enforced. For example, it should be known beforehand what the safety measures are should spillage of a toxic liquid occur.

4.442 Clear instructions can contribute to the safety of users. Easily-identifiable labels on poisonous products warn users about the dangers related to such products. However, there are risks which may be so gradual as to pass unnoticed for a long time. There should also be clear warnings in such cases. The inhalation of small quantities of fumes from chemicals and the development of an allergenic reaction to certain types of live specimens, illustrate the case in point.

Does your RDI have any work-in-process or finished goods? If so, are they valuable?

Does it look that way when one examines the stores in your RDI?

What is the impact of having nobody really responsible?
4.511 Storage Areas: Instructions are not sufficient to protect individuals adequately against dangerous materials. Some measures concerning the location and layout of storage areas should also be considered.

4.512 Storage of poisonous and radioactive materials is regulated in certain countries. When such regulations exist, it is imperative that RDI officials make sure that these be adhered to. In countries where no such regulations exist, or where these are not believed to be adequate, RDI officials should follow more severe regulations and use expert advice if necessary.

4.513 Such experts — whether they come from inside or outside the RDI — could make recommendations on suitable locations, layouts, and other safety measures which could at least alleviate problems with hazardous materials.

4.514 Lack of storage space does not always make it possible to store safely these type of materials. Fences might not be sufficient. Consideration should then be given to store these materials away from the main premises of the RDI. Doing so would reduce the risks inherent in having to control a large quantity of dangerous chemicals stored in a location where there are many people.

4.515 Finally, special storage systems such as locked premises, are necessary to eliminate about all risks of misuse or stealing. For instance, drugs and mercury are good examples of materials subject to such risks.

4.52 There are not only safety considerations which should prevail. Basically, the location of storage areas should facilitate the receiving of materials and their subsequent distribution to users. Storage areas are only temporary locations where it is possible to keep control over items not yet required by users.

4.531 It is important to emphasize in this chapter also that shortage of storage space should be seen as a consequence rather than as a cause. Proper consideration should be given to causes

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Are there dangerous materials in your RDI? If so, how adequate are safety measures?

If necessary, is consideration given by RDI’s top officials to suitable outside storage locations?

Discuss this idea with other participants or colleagues to test their reaction.
such as inadequate storage areas throughout the building, improper storage techniques, obsolete inventories, and excessive quantities ordered.

4.532 Storage areas are not simply places where to put away items. When this is the case, there is a possibility that materials will be stored improperly. The layout should be well planned in order to avoid having a random location for items to be stored. Identification of items in storage should not depend mostly on the storekeeper's memory and experience. The variety of materials already makes the layout complicated enough to determine, without being able to rely on a logical identification system.

4.533 Suitable layouts allow a turnover of perishable and other types of materials (usually liquids). If necessary, stock already on a bin should be taken out, and replaced in front of newly arrived— and thus more recent—stock. If this is not done, monetary losses might result. This type of problem is usually not solved by simply hiring more storekeepers.

4.534 Proper stores codification could contribute to improve inventory control. A codification system such as the following could be used: each side of a row could be identified by a letter, while each shelf would be given a number. The first digit could correspond to the actual position of the shelf as compared to others below and above it.

4.535 For example, if there are 10 rows, a maximum of 5 shelves in height and 60 different types of items, an acceptable codification could be: rows A to T (20th letter of the alphabet, because there are 2 sides for each row), first digit 1 to 5, last 2 digits 1 to 99 (allowing for flexibility for new items).

4.536 It should be emphasized that the codification system chosen should take into consideration the actual and expected modifications to the existing layout, the size and nature of the items stored, and some flexibility for new types of items.

Are the following factors having a negative impact on the storage space available in your RDI? (Circle your answers).

(1) Inadequate storage areas? Yes No
(2) Improper storage techniques? Yes No
(3) Obsolete inventories? Yes No
(4) Excessive quantities purchased? Yes No

If 2 or more answers are positive, these would emphasize that shortage of storage space is more a consequence than a cause.

Case #4.1:
An industrial research centre has good procedures and it is made sure that these are adhered to. However, it had far too many storekeepers, considering that the volume of transactions was low. Few persons realized this situation.
4.537 There is no point in storing temporarily items which are immediately required by a user. In such a case, proper consideration should be given to sending these materials directly to users. However, as it has been noted previously, this procedure should be made only on an exceptional basis, because the updating of stock records might not be done at all. It is an apparent tradeoff between a lack of space in the receiving department or in the stores, and the risk of inaccurate records. There will likely be few such problems in RDIs where strong control procedures exist.

4.61 Valuation: To keep in mind that inventories are costly is a necessary first step to ensure that efforts will be made to control quantities ordered, but also all items on hand. A proper valuation helps to put materials into an even more concrete form, an identical unit measure named "money". Accurate stock records facilitate valuation by making possible to know at all times the financial value of inventories.

4.621 It is improper accounting to charge all incoming materials to expenditure without adjusting this figure at year-end to reflect the value of inventories on hand. It would not be better to presume that all purchases would go into stock, without adjusting for consumption.

4.622 While proper stock records should eliminate this problem, this is not always the case. Unfortunately, it is not obvious to all those concerned that the value of stock on hand as per stock records, correspond to items not yet used and, therefore, to be considered as an expenditure only in the following year.

4.623 To consider all materials as an expenditure increases costs erroneously when inventories are higher at fiscal year-end than at the beginning of that same year. The opposite is also true, as can be deduced from Exercise 4.9. Work it out with an example of your own.
Exercise 4.9: Impact of considering all incoming materials as an expenditure rather than as an inventory

Situation:

An RDI with large quantities of chemicals on hand at year-end, has always considered all incoming stock as an expenditure, therefore showing no inventory on hand at year-end. It is now asked by a government official having to endorse the budget presented by the RDI, to justify its high usage of chemicals for the preceding year.

Last year's ending inventory was estimated to be $40,000, while this year it would be worth $85,000. Annual consumption of quantities purchased during the year was $140,000. What would be the impact of considering ending inventories as an asset, rather than as an expenditure?

Do NOT read on unless you want to compare your solution with ours.

Solution:

Presently, annual expenditures are $225,000. This figure comes from ($140,000 + $85,000). If proper consideration would have been given to adding beginning inventory to the actual consumption of the current year, there would have been no reason to consider the current ending inventory figure as if it would have been used during the year. Therefore annual chemical expenditures for the current year would have amounted to:

$40,000 + $140,000 = $180,000.

This amount is 20% less than the $225,000 originally computed!

4.624 The practice just mentioned is clearly an unsuitable management practice which may lead to wastage of scarce resources. It is indeed possible that proper planning of RDI funds will be difficult if accurate figures are not known.

4.625 There are important consequences at the national level. Governments allocate funds on the basis of requirements. It is obvious that an RDI showing no inventory balance could claim more money than one showing an important amount for inventories on hand. This could happen despite the fact that both RDIs might have a similar year-end inventory value.

4.626 Therefore, unless government officials are aware of the impact of this situation and act accordingly, additional financing to RDIs charging all materials to expenditure is likely. Doing so represents a misallocation of funds, and could contribute to demotivate some RDI officials trying to use their resources efficiently.
At year-end, inventories are usually evaluated at cost. Cost is determined by using one of the methods already described — FIFO, LIFO or weighted average cost—or any other method found to be appropriate. In certain cases, governmental policies might exist to determine the method to be used.

When the market value differs substantially from the original cost, it could be useful to decision-makers to know what that value is. For instance, it might be possible to take advantage of temporary price declines.

Valuable End-products: In certain RDIs, the end-product of the research and development effort may be a commercially useful product. The value of such products should be included in the financial statements of an RDI only when it can be reasonably estimated. If it is not yet a product, then it is inappropriate to include a value for potentially marketable products. However, the situation should be carefully monitored.

Procedures for the determination of what is sellable and what is not do not always exist and in such cases, the discretion of the research personnel or head of RDI may be the only option. This is clearly an area which needs attention since some of those products may not only be quite valuable but also constitute a significant part of the RDI's revenue.

When research personnel are quite aware of the state-of-the-art in their area, they might be good judges at evaluating the potential outside interest in their findings. This situation is not necessarily applicable at all times, since the findings could have much interest in areas quite different from the area they are familiar with.

In cases where it is believed that potential applications can be found or already exist, it would be appropriate to ask outside agencies to assess the marketability of certain products of the RDI.

It is likely that only a few RDIs are more likely to develop marketable products.
Accordingly, it is mostly these RDI s which should be monitored in that respect. Governments invest substantial amounts for national development, and it is only normal that the whole nation benefits from RDI discoveries. 

4.646 However, there is a note of caution. To operate an RDI and to develop a product for commercial applications are quite different activities for RDI s not specifically oriented on development. Therefore, it is suggested that the commercial aspects — and in some cases the development of products — be left to other institutes or organizations better equipped and more oriented to succeed in such an undertaking.

4.71 Disposal: Even materials which have lost part of or all their value, still cost money when they are not disposed of. They occupy space and may even be insured.

4.72 Where surplus or unusable materials have to be disposed of, there is a need to have clear guidelines and policies indicating the procedure to be followed. This was not the case in some of the RDIs visited, as evidenced by the fact that nobody was responsible for such disposal.

4.73 There are a variety of ways to determine that some items in stock are obsolete or unusable. For instance, slow-moving items can be identified from stock records, physical stocktaking could help to determine damaged items, researchers may know some materials which are held and will likely not be used for a variety of reasons, etc. As soon as it is decided to dispose of some materials, efforts should be made to actually dispose of them rapidly, because it could be possible to obtain some money instead of nothing at all.

4.81 Conclusion: Materials come in a variety of types and forms. Research activities require that many materials be controlled and used. Decisions such as quantities to order and reorder points can be improved by adequate controls, including accurate stock records.
PROCEDURES MANUAL OUTLINE—MATERIALS

I—DEFINITIONS

In these instructions “stores” means the division charged with the receipt, storage, safekeeping, issue and replenishment of commodities which have to be readily available for the purpose of RDI’s activities.

“Storekeeper” means the officer charged with the management of the stores.

II—STORES STOCK

2.1 Stores stock consists of commodities whose keeping on hand has been approved on one of the following grounds:
   (a) Items required regularly and not once;
   (b) Items not readily available from trade outlets;
   (c) Items of strategic importance;
   (d) Items which have to be stored with special care due to physical characteristics for example, flammability or explosiveness.

2.2 The total monetary value of stores stock shall not exceed an amount determined and approved by the Governing Authority of the RDI.

III—RECEIPT, DISPATCH OF GOODS AND RECORDING OF STOCK

3.1 With the exception of postal articles e.g. a parcel, all items delivered to the RDI, whether stores stock or other items on order shall either be delivered to the stores or declared to the storekeeper within 24 hours after receipt.

3.2 Except for postal articles, all items dispatched by an RDI, whether empty containers, or unsatisfactory purchases returned to supplies, shall either be handed in at the stores for dispatch or arrangements for dispatch shall be made by the storekeeper.

3.3 No article for the private use of any individual shall be received or dispatched by the stores.

3.4 On receipt, stores stock shall:
   (a) be classified and stored according to its physical nature or as indicated by special storage requirements;
   (b) all items shall be identified in a recognizable manner, and
   (c) shall be entered on a stock record or stores ledger in appropriate units of issue such that they represent the taking of stores on charge.

3.5 Stores rejected or under dispute should be set aside and not taken on charge in the stores record or stock ledger, and the facts should be brought to the attention of the procurement department/division.
IV—ISSUE OF STORES STOCK

4.1 Stores stock shall be issued on the basis of a stores requisition and issue voucher duly authorized by the section head or departmental/divisional head with appropriate signing authority. The responsibility to ensure that requisitioned supplies are in fact destined for official RDI use and will be economically used, rests with the officer who approves the issue.

4.2 All issues shall be entered in the stores stock record card or stores ledger.

4.3 Stores items shall be issued at a cost of the item concerned on a method as determined by the RDI. The cost shall be debited against the job code or department appearing on the requisition and issue voucher.

4.4 Stores stock shall, upon issue, pass to the requisitioning division. The stores officer may in his discretion, take back into stock unused items returned to the stores in undamaged condition and in complete units of issue and may extend credit accordingly.

V—REPLENISHMENT OF STORES STOCK

5.1 On the basis of:
   (a) average consumption,
   (b) delivery period,
   (c) available storage space,
   (d) economic order volume,
   (e) ageing or deterioration during storage, and
   (f) with regard to 2.2, the storekeeper shall determine in consultation with the division/department concerned a minimum stock level as well as a suitable order quantity for each item of stock.

5.2 As soon as an item reaches the minimum stock level, it shall be replenished in accordance with instructions as to the procurement of stores (and other applicable provisions of the buying procedures).

VI—SAFEKEEPING OF STORES STOCK CONTROL

6.1 Precautions shall be taken to protect stores stock during storage against losses as a result of theft, fire, damage or loss of quality due to ineffective storage.

6.2 Unless he is accompanied by the storekeeper or a fulltime stores officer, no other employee of the RDI or a member of the public may enter the stores.

6.3 The stores officer shall report surpluses and shortages in the stores stock as well as damaged items discovered by him. No adjustments of the stock records may be made without proper authorization.

6.4 Stores stock shall be subject to periodic checks by a senior officer (versed with the accounting procedures) other than the stores officer. An annual report shall
be prepared in which mention is made of:
(a) surpluses and shortages discovered;
(b) general physical condition of stock;
(c) obsolete stock;
(d) any other aspect which may come up for the RDI’s governing authority’s attention.

VII—STORAGE OF UNSERVICEABLE ITEMS

Unserviceable items should be kept in a separate place from serviceable items, in order to prevent substitution.

VIII—DISPOSAL OF UNSERVICEABLE ITEMS

Unserviceable items may be disposed of:
(a) in a manner as recommended by the Board of Survey and approved by the governing authority when the total value involved warrants the appointment of a Board of Survey;
(b) in a manner as recommended by the chief executive and approved by the governing authority when the total value involved does not warrant the appointment of a Board of Survey.
MATERIALS: Selected readings for more study


Bartholomew, Dean. “Block Counting to Achieve Inventory Record Accuracy”. P&IM Review; August, 1984: 40-42.


MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D INSTITUTE FACILITIES AND MATERIALS MANAGEMENT

CHAPTER V

LAND
LAND

Training Objectives

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

1. Identify the key factors in the location of suitable land.
2. Explain the impact of existing ownership on acquisition procedures.
3. Relate ownership of land and records.
4. Know the reasons for valuation.
5. Consider aspects such as environment and security.
LAND

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All of this material can be covered in one session, if it has been studied on an individual basis prior to the session.
CHAPTER V

LAND

5.111 Introduction and Initial Considerations:
Land is a valuable and scarce commodity. Therefore, it is important that RDI managers plan its acquisition and its use accordingly.

5.112 Land comes at a cost for a nation, although the government often yields its use to RDIs. This reality is not obvious, due to the widespread idea that there is much land available. However, a piece of land used for a specific purpose is not available later for other purposes. This choice might not be known specifically when the land is yielded by the government to the RDI, but it is nonetheless a national choice. An appropriate long-term plan by the governmental authorities is a must.

5.113 This chapter deals with many facets of land, including approval, records, valuation and environmental considerations. At the end, it includes an outline of procedures on land and buildings, because these two aspects are closely related. This outline provides a good summary of the important aspects to consider for land and buildings.
5.12 Definition: Land is the surface of the earth and its natural resources. It is the property of governments, other public or private organizations, or individuals. The owner is usually entitled to sell, to lease or to give pieces of land that are his property.

5.131 The acquisition of urban land often represents a bigger problem for RDI managers than the acquisition of rural land. Competition in urban areas might be particularly stiff for the available space, with the result that prices asked for can be very high. This situation is true for some large cities and for some parts of cities already completely developed. In some cases, existing buildings might have to be demolished or converted at a cost for the RDI.

5.132 The restricted availability of urban land also represents a limitation from the standpoint of the number and appropriateness of available locations. The choice might have to be made among locations that are available, without much consideration for meeting important selection criteria, such as the ones that will be discussed subsequently. In certain cases, existing buildings will be used for purposes which they were not built for, and which are inappropriate.

5.133 The availability problem is not as acute for rural-based RDIs, because large tracts of land are usually available. Thus, it is likely more expensive to acquire an appropriate piece of land in a city than in the country.

5.134 Industrial and commercial companies are mostly interested in urban land because cities provide a larger manpower and customer pool than villages. Accordingly, there is more competition for urban land. Unless there are major reasons for an RDI to locate in an urban area where land is expensive, it is preferable to locate away from expensive industrial and commercial land. The savings realized at this stage could eventually be used for other productive purposes.

5.135 When land has to be obtained from the government, the permission might be granted more easily, due to the few alternative productive
uses likely considered by government authorities. When land not requested is offered to an RDI, this does not mean that it should be accepted immediately. It might be preferable to assess beforehand the likelihood of obtaining soon a more adequate piece of land than the one originally offered.

5.141 Initial Considerations: The choice of a poor or even of a wrong location represents a substantial cost, not only for the RDI, but also for the nation as a whole. An RDI with inefficient operations hinders national development, because resources are poorly used.

5.142 The selection of a location is a strategic decision and its importance should not be downplayed by managers. RDI operations simply cannot be moved frequently from one location to another, not only because of the moving costs involved, but also because of the disruption to the regular activities of the organization.

5.143 The fieldwork revealed that the location of many institutes seems to be due to historical development rather than to specific planning. Consequently, the efficiency of some RDIs is reduced; it simply cannot be compensated by good management or by additional efforts of researchers and staff.

5.144 To locate an RDI does not imply that the cheapest or most readily available land will be appropriate. It is indeed obvious that not just any piece of land is suitable for the activities of a specific RDI. All required efforts must be made to determine a reasonable number of pieces of land which appear suitable for the intended purpose.

5.145 Legal requirements such as maximum height of buildings, environmental policies, and restrictions on the nature of the activities of organizations operating in certain urban districts, should be considered prior to the acquisition of land. It is often easier to locate elsewhere than to modify substantially original plans.

Has there ever been a change of location in your RDI? Do you think that there should be one within the next 10 years? Why?

Is this the case for your RDI? If so can you think of one type of situation where the efficiency of operations is reduced due to the location being related to historical reasons?
5.151 Selection criteria are factors used as a basis to compare all options. There are objective factors such as acquisition cost, and subjective factors such as preferences of top officials of the RDI. The final selection of a location is influenced by a variety of factors, including the nature of the operations of the RDI, the actual or intended uses for adjacent land, the cost of the land and the expected growth of the RDI.

5.152(a) The nature of the operations is a particularly important factor, because it limits substantially the number of reasonable options for a location. It could even be argued that constantly keeping in mind this factor and the specific purpose for the acquisition of land should reduce substantially the likelihood of selecting a poor location.

5.152(b) RDI with operations focused on agricultural research on products such as coffee, will likely locate close to appropriate areas where coffee fields are or could be situated. This situation is similar to the one of companies located close to their suppliers of raw materials, because the transportation of such materials is particularly costly. However, should research be performed which does not require closeness to the coffee fields, then a site close to or in an urban area would likely be at least as appropriate as a rural site.

5.153(a) Adjacent Land: The activities going on close to where the RDI would operate might be incompatible with and even detrimental to the activities at the RDI. Therefore, existing activities should be determined whenever adjacent land is used. For instance, the location of a toxic chemical plant next to an agricultural research institute may have adverse effects on research work going on in the RDI. Similarly, an old wooden building on an adjacent land constitutes a high fire risk, particularly when it is close to highly flammable chemicals.

5.153(b) The situation becomes more complex when adjacent land is not used at the time the location decision must be made. If it is private property, it might be subsequently sold and RDI
managers could very well have no influence on the use of the land, unless they decide to purchase it.

5.153(c) If the land is governmental property, it is more likely that RDI managers can influence the decision process regarding the intended use of the adjacent land. For doing so, they need good contacts in the appropriate ministries, at least to be told about the intended use. It is also in the best interests of the government and of the country that the national objectives carried out in the RDI be as efficient as possible. Thus, inappropriate use of a land adjacent to an RDI is unlikely if RDI managers make sure that they will be informed should there be an intended use for the adjacent land.

5.154 The cost of the land sometimes acts as a major barrier. There are situations where the land has to be purchased, particularly when the land looked for is in an urban centre. As mentioned earlier, this type of land can be quite expensive, and possibly too expensive for the RDI to afford. Naturally, the acquisition cost criterion becomes negligible for the RDI when the land is government-owned.

5.155 The expected growth of an institute should be considered very carefully, particularly for the consequences it might have on the number of staff and facilities required to perform the planned workload. If the growth is under-estimated, a new location might be completely unsuitable in five years.

5.156(a) For the selection of a site for an RDI, governments are likely to take political considerations into account, at least to a certain extent. Although governments usually provide most RDI funding and can approve or not the final location and other reasonable options, it is tempting for them to consider factors such as the unemployment rate and the number of voters who could be favorably influenced by each of the options.

What is the expected growth of your institute for the coming 5 years?

Do you think that political considerations had any impact on the location of your RDI? If so, how?
5.156(b) A site selected in great part for political considerations is likely not the best location in terms of efficiency of operations. If it is not, then the choice runs contrary to national interests. For this reason, it is important that top RDI managers make very clear to top governmental officials the reasons for the selection of the site suggested to these officials.

5.156(c) This is not to say that RDIs should not consider at all regional development issues when setting project development. However, it is likely that the government might put much emphasis on achieving rural development goals.

5.157(a) Personnel is the most important resource of an RDI. This is why the availability of personnel both in terms of quantity and with an appropriate background is so important in the choice of a location. Figures on both counts are usually available from one of the governmental agencies. If the required personnel is not available locally, it is not reasonable to assume simply that qualified personnel will accept to move or to be relocated.

5.157(b) Furthermore, an RDI becoming a major employer, assumes a major social role in the surrounding region. It is unlikely that other moves will be possible, both for social and political reasons. This is an example as to why the selection of a location bears long-term implications.

5.158(a) Finally, the availability of services such as proper transportation, electrical power, water, etc., may represent a prerequisite for consideration of a site as a valid option.

5.158(b) The reliability of suppliers, their delivery schedules, the proximity of airports and harbours are all factors which influence operational aspects such as the quantity of materials still on hand at the time of replenishment of inventories.

Case #5.1:
An international RDI opened a station in a remote part of the country. The economical impact was very important. Accordingly, the local MP got much publicity out of it.

Presently, the MP in an adjacent riding is trying to obtain the opening of a sub-station in his own riding.

Provide examples of the social role of an RDI.

Can you explain briefly how (although these notions will be covered later)?

5.161 Available locations might not be as appropriate as managers would have hoped initially. This is a normal situation, because expectations often exceed reality. However, managers
should make sure that at least one location meets sufficiently well the established criteria. If this is not the case, it might be preferable to examine other locations, rather than to make a poor choice.

5.162 There are usually a number of apparently satisfactory locations to choose from. Each one has its advantages and disadvantages, which is the reason in the first place why an analysis and discussions should be done.

5.163 There are three types of approaches used for the selection of a site: arbitrary approaches, quantitative approaches, and semi-quantitative approaches. They can also be combined in order to provide more information to the decision-makers.

5.164 Arbitrary approaches are based on intuition, experience and judgement. They are not necessarily always less appropriate than the other ones, but they lack the support of most of the quantitative information.

5.165 Quantitative approaches suffer from the opposite tendency: a lot of computations are made, often resulting in a substantial amount of quantitative data. Managers are then tempted to select the alternative showing the best results, without giving appropriate consideration to qualitative elements. The location of a central materials warehouse for an RDI with many locations provides a good example for the case in point. A mathematical method named linear programming would be used in this case. Most operations research books explain in depth how to use such a method.

5.166 Semi-quantitative approaches are based on the selection of weighted criteria: A coefficient is attributed to each criterion, based on the relative importance of these factors. The evaluator gives a value to each site for every criterion, multiplies the value by the coefficient, and adds up the numbers obtained. The totals are then compared, and the site with the highest figure is the one selected. Example 5.1 and Exercise 5.2 are based on a semi-quantitative approach.

Do you know other instances, than the selection of a location, where an arbitrary approach could be used for facilities and materials management?

In summary:
(1) Determine the criteria.
(2) Give them an absolute value (say from 1 to 5 or 10).
(3) Evaluate each site for each criterion.
(4) _________________________
(5) _________________________
(6) _________________________
**Example 5.1: Semi-quantitative approach**

**Situation:**

There are three sites, A, B, and C, which seem appropriate to hold the operations of an RDI having outgrown the existing site. Four important criteria have been retained:

1. Closeness to a water stream (in kms);
2. Cost of the land (in $);
3. Closeness to a key supplier (in kms);
4. Space availability for future expansion.

Each site has the following characteristics with regard to these criteria:

<table>
<thead>
<tr>
<th></th>
<th>Site A</th>
<th>Site B</th>
<th>Site C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>4 kms</td>
<td>2 kms</td>
<td>0 kms</td>
</tr>
<tr>
<td>Land cost</td>
<td>$10,000</td>
<td>$30,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Supplier</td>
<td>15 kms</td>
<td>15 kms</td>
<td>50 kms</td>
</tr>
<tr>
<td>Space</td>
<td>None</td>
<td>Plenty</td>
<td>Little</td>
</tr>
</tbody>
</table>

Which site should be chosen?

**Solution**

1. The criteria have already been determined.
2. The absolute value attributed to each factor is respectively: 10, 8, 5 and 3.
3. In this case, the evaluation of each site for each criterion is based on a scale from 0 to 10:

<table>
<thead>
<tr>
<th></th>
<th>Site A</th>
<th>Site B</th>
<th>Site C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Land cost</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Supplier</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Space</td>
<td>0</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

4. and (5) the values attributed in step (3) are multiplied by the weight of each criterion, and the results obtained are added for each site:

- Site A: \[ (10 \times 5) + (8 \times 8) + (5 \times 4) + (3 \times 0) \] = 134
- Site B: \[ (10 \times 7) + (8 \times 4) + (5 \times 4) + (3 \times 10) \] = 152
- Site C: \[ (10 \times 10) + (8 \times 2) + (5 \times 1) + (3 \times 2) \] = 127

(6) Based on this evaluation, site B should be selected.
Exercise 5.2: Semi-quantitative approach

Use basically the same figures as in Example 5.1, except for the following additional information: you have just learned that it appears that the government will not approve any further expansion after this one. How would it affect the weight of the above criteria? Would the site selected above remain the same?

5.21 Approval: The acquisition of land should be authorized by the governing authority of an RDI. Actually, it is likely that he will be involved in the discussions and selection of the final site, because it is such an important decision for the RDI.

5.221 Although the land selection process might require a lot of time, the internal approval process usually goes well, for the reasons just mentioned. It is the governmental approval which takes long: the fieldwork revealed that delays of one year were not uncommon.

5.222 Total time required from the determination of the need for additional land to final approval by all parties can take well over two years. This period is long, considering that quite often little planning is done and acted upon regarding the acquisition of land: when the need becomes urgent, then the necessary efforts are put into proceeding with the appropriate steps.

5.223 It appears that RDI managers could accelerate the whole process and still select prop-
erly and not hastily, just by acting upon their long-range plans, including beginning early discussions with governmental authorities.

5.231 Procedures for requisitioning additional land from government should be developed so that it is known how to go about the process of getting the land. Governments are the owners of much land in each country, which explains in part why RDIs get additional land mostly from them.

5.232 The procedures are usually similar from time to time. A proper written description of such procedures would contain the detailed steps with the titles of the persons involved. Titles of individuals are used instead of their names, because changes of position are likely in both the government and RDI organizations.

5.233 Obtaining governmental approval takes longer and requires more procedures when there are many ministries and agencies involved, than when it is not the case. The problem then becomes one of coordinating with the appropriate central and local government authorities so that permission to use the land can be granted quickly.

5.234 Even when the land is acquired from private interests, it is often necessary to obtain authorizations from the appropriate government officials, because of the restrictions which exist on the use of the land and the obligation that RDIs are under to get approval for such matters.

5.24 Obtaining the proper approvals by going through the necessary procedures is a process which can be speeded up by demonstrating clearly the need for the RDI to get rapidly the required authorizations. For doing so, RDI managers should demonstrate how the local community and the nation as a whole would benefit, considering that the RDI was created in the first place for contributing to national development.

5.251 Ownership: The acquisition of land sometimes constitutes an important step to improve the efficiency of the operations in an RDI. However, the acquisition becomes official only when the RDI has the proper documents to estab-
lish its ownership or its right to use a piece of land according to the permission granted by the proper authorities.

5.252 In most cases, the land to be acquired may be controlled by government. As such, relevant documents and records are necessary for RDI managers, say in cases where there are possibilities of frauds. As a result, it is recommended that before finalizing the acquisition procedures, RDI managers should make clear distinctions between ownership and possession, joint tenancy, whether the land is freehold or leasehold and any other conditions of ownership existing.

5.253 For instance, in joint tenancy, the owner of the land is not the same as the owner of the buildings thereon. What happens if the owner of the land wants to sell it? To what type of use is the owner of the buildings limited if he is not also the owner of the land? As can be seen, joint tenancy calls for clear documentation.

5.261 If an RDI owns land — whether it has been purchased or accepted in donation — the title documents should be held in a safe or in a vault. The same applies for written authorizations to use land. These documents will prove invaluable, should there be later any discussion regarding the rights of the RDI.

5.262 One person could be responsible for the title documents, as part of his regular duties. That individual would be identified as such, which would save time to try to identify in the first place who could know where the documents are held.

5.271(a) Ownership documents are also useful when an RDI wants to acquire land or even to lease land. In negotiations with farmers, there should be written evidence as to who can use the land and get the proceeds from the sale of the crop.

5.271(b) It is then necessary to determine where the title deeds are held and whether land is leasehold, freehold or under joint ownership and other conditions of ownership. It is also important to know who the registered owner is, particularly

Is there a safe or a vault in your RDI? If not, why not?
if the land is private property. This approach ensures that discussions will be held only with the appropriate persons or organizations.

5.271(c) RDI managers should always bear in mind that land left unused for a long time might invite interests of pressure groups within the community to repossess it.

5.272 There are two other advantages derived from this approach: firstly, the value of the previous transaction on the land will be known, allowing to determine the reasonableness of the amount asked for by the potential seller; secondly, it should be possible to determine if the title is in dispute. If this is the case, a lawyer should be consulted.

5.28 Lawyers are experts in titles on land and on buildings. A manager should not hesitate to call on a lawyer, whenever necessary. The fees incurred might be compensated many times by the costly errors avoided.

5.31 Records: Title documents are justified mostly for legal reasons. However, they are not useful for the daily operations of an RDI, because they are used nearly exclusively at the time of selling or in case of dispute with other organizations.

5.32 RDIs need more written information on land owned or occupied than what is included in the title documents, although these documents provide appropriate information on the dimension, geographical location and cost of land acquired.

5.331 Large agro-research RDIs in particular would benefit from records showing in detail the specific uses of the whole property and areas falling under each category. For example, the different varieties of maize should be clearly identified on the field and in the records, so that even an outsider would be able to determine that it is not just a single crop.

5.332 In fact, fieldwork revealed that for RDIs with land in various parts of the country, there

Have lawyers been used frequently in your RDI? For what specific purposes?
were not always adequate records to show the location, size and use to which the respective parcels of land have been put to use.

5.333 Changes in personnel constitute another reason why it is appropriate to have such information in writing. Furthermore, even if there would be no change in personnel, it is unlikely that anybody would remember the specific agricultural use of all land that is the property of an RDI. Because of the importance of having a rotation of cultivated products and of laying land fallow over a certain period of time, accurate records might contribute to the efficiency of operations of agro-research RDIs.

5.334 Advantages for urban RDIs are not as obvious, although appropriate records could help to identify the plans made for the land at the time it was acquired or subsequently.

5.41 Valuation: During the course of the fieldwork, it was found that valuation of land for financial reporting purposes was a problem both in those institutes which either own the land or are holding it in trust for the government. There were cases where the value of the land was not known or the evaluation had been carried out more than three years ago. Unawareness of the possible advantages of a regular valuation probably explains such a situation.

5.421 Although, for financial statements purposes, land is customarily shown at cost rather than at market value, it is sometimes required that the latter amount be also indicated. The market value helps to determine the actual value of all assets owned by an RDI.

5.422 The cost of land does not appear in the financial statements of an RDI when the RDI does not own the land. However, because most of the time the owner is the government, an evaluation would enable the RDI to report how it has used the land, considering its market value. In fact, allowing RDIs to use public land represents an investment which could also be used in a different manner, namely by selling the land to private interests and investing elsewhere.

Is there much personnel turnover in your RDI? Whether your answer is yes or no, what positive and negative impact does it have on the organization?

Do you agree that governments invest funds in RDIs when they let them use public land? Why?
5.423 It should be noted that in some countries, value is placed only on the development made on the land such as buildings, water supply and crop development.

5.43 RDI managers could use the value of land to make more appropriate decisions regarding its use. For instance, it could indicate that it would be too costly to acquire adjacent land which is private property, or that a poor utilization is presently made of valuable land. This is particularly true for urban RDIs, because greater local demand for land and available space in general increases the likelihood of important increases in value.

5.441 It is worth the cost to have professional appraisers evaluate land regularly, particularly when the information is valuable for RDI managers. The managers are really the ones who should be convinced of the benefits of going through this valuation exercise. If it is determined, after a close examination of the benefits and costs, that a regular valuation by RDI personnel is sufficient, then let it be so. The best source of information would then be the value for which similar land sold recently.

5.442 A professional appraisal could also be useful when it is time for the acquisition or the disposal of land. This appraisal represents the best assurance that the price paid or obtained is fair.

5.443 Eventually, an appraisal could also be used as a basis of discussion with the government to obtain land of equivalent value, should it be necessary for the RDI to move.

5.51 Other Considerations: So far, we have covered few aspects dealing with the utilization of land as such. This section deals with increasing the capacity of land through better use of land, but also covers some environmental considerations and security measures.

5.521 Improved Capacity Planning: Problems with available space are often considered to be solely related to buildings; this is not a correct view of the situation, and neither is the opposite situation. The next chapter will cover capacity
problems in the use of buildings. However, it is also necessary to examine the utilization of land.

5.522 Past decisions, such as the construction of buildings, limit the flexibility available to managers in modifying the utilization of land. Some previous decisions, which were justified at the time they were taken, might appear otherwise a few years later. Long-term planning does not guarantee that decisions will remain appropriate ten years hence, but rather that the utilization of land will take into consideration all long-term objectives.

5.523 Long-term plans or low cost might even justify the acquisition of more land than what is needed in the short-term. There are also reasons like the ones mentioned in the first section of this chapter — incompatible use of adjacent land, etc. — which justify such an action.

5.524 It should be remembered that there is not only the acquisition of adjacent land which helps to solve space problems; moving the RDI sometimes represents a better solution, because it eliminates some of the constraints which would have to be faced otherwise. Another option is to move part of the operations elsewhere. Although it appears to represent increased coordination costs, practice teaches that two smaller organizational units are usually easier to manage than a large one.

5.531 Environmental Considerations: Many RDIs use toxic materials or have operations which are potentially hazardous for the environment. Some governments have passed laws to try to prevent environmental damages. In Kenya, for instance, there is now a legal requirement which has forbidden direct discharge of effluent from a factory into the adjacent waterways.

5.532 Inadequate soil conservation measures on idle land may lead to soil erosion. Where both the climate and the intended future use allow, planting trees could be a relatively inexpensive solution. Trees also contribute to reduce the severity of strong winds on nearby crops.

5.533 There might be cases where RDI personnel, by using idle land for their own benefit, could
reduce soil erosion and, to a certain extent, undesirable vegetation. However, RDI managers should be very cautious before granting such permission. It is advisable not to allow personnel or other individuals use land that is the property of the RDI, for personal purposes.

5.541 Security: Unauthorized individuals should not be tempted to get onto the RDI land. It is obvious that useful security measures and principles applying to land are closely related to security for buildings. Accordingly, some measures which are applicable mostly to buildings, are mentioned only in the next chapter.

5.542 Perimeter fencing is recommended if funds allow; however, growing of hedges is equally desirable where security is not paramount. These methods often discourage most of the unauthorized users whose presence could interfere with research work. Although this observation is particularly applicable to rural-based RDIs with large tracts of land, its importance to urban RDIs should not be underestimated.

5.543 The presence of security guards at entrance gates also acts as a deterrent for intruders. Limiting the number of entrances to a few only, and controlling them properly could reduce substantially the security costs for buildings. Otherwise, when there are no fencing or no gates, it is necessary to post guards nearly exclusively around and in the buildings.

5.544 Visitors to an RDI could be asked not only to identify themselves and to justify their visit, but also to be endorsed by an authorized member of the RDI and to wear an identification sign. These additional procedures put the responsibility for visitors on RDI personnel, and aim at eliminating unsolicited visitors.

5.545 Security guards touring regularly the premises, including idle land, demonstrate the commitment of RDI managers to security. However, all RDI personnel can act as members of the security team, simply by keeping their eyes opened for intruders on RDI land.

Which of the following security measures are used for your RDI? 

<table>
<thead>
<tr>
<th>Perimeter fencing?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security guards?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gates?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitor identification?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitor endorsement by an RDI person?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do you see other alternatives?

Would mandatory endorsement by an authorized member of the RDI be justified for all visitors? Justify your answer.

RDI personnel are more than simple workers when they are committed to their organization. Do you agree with this observation? If so, provide other examples than security. If not, why not?
5.55 Security personnel are useful only if they do their job correctly. They should be properly trained and be given all explanations on security measures applicable to the RDI. A very circumspect selection of the security guards or of the security agency should go a long way in increasing the efficiency of the security system.

5.561 Important security measures are justified mostly for RDIs doing sensitive research or development work, or using dangerous materials. A decision should be made as to the level of security that is justified, considering the security costs vis-a-vis the risks involved and the costs associated with a lack of security. Figure 5.1 represents this tradeoff.

5.562 In general, security efforts should be proportional to the costs that would be incurred without such procedures. In certain cases, this tradeoff implies that some security measures could be too expensive for the benefits they provide to an RDI.

Figure 5.1. Determination of the Optimum Level of Security

5.61 Conclusion: Land management is important particularly because of the long-term impact of a decision such as the location of an RDI. It appears that areas such as records, valuation and even security have often been neglected, despite their potential contribution to the success of RDIs. Proper consideration should be given to devoting more time to these aspects. At least, if they are still neglected by some managers, these managers will have decided after much thinking.
PROCEDURES MANUAL OUTLINE — LAND AND BUILDINGS

I— PROCUREMENT

The procurement of land and/or buildings is an important aspect of every Research and Development Institute. Careful procedural steps need to be adopted.

(i) Determination of requirements for land or buildings based on RDI activities and projects both current and for future plans is a decision to be made by top management.

(ii) Identification of suitable location based on same criteria.

(iii) Determination of ownership status, e.g. for land whether the desired area falls under leasehold or freehold category and for buildings, the examination of title documents.

(iv) Formalizing the process of acquiring land or buildings through local authorities and/or government ministries.

(v) Assessment of value in case of purchase. Determination of rent to be paid and period in case of renting.

(vi) Payment authorization, payment and completion of legal formalities.

(vii) Recording and custody of title documents.

II— MAINTENANCE

(i) Determination of responsibility for maintenance, e.g. appointment of Estates officer (manager) and his/her position on the organization chart.

(ii) Policy decision as regards preventive maintenance and corrective maintenance, contracting out or in-house maintenance.

(iii) Preparation of maintenance plans and budgets.

(iv) Implementation procedures of the maintenance plans.

(v) Appropriate security measures in regards to land and buildings.

III— VALUATION

(i) Determination of valuation period, i.e. periodicity.

(ii) Appointment of competent/authorized valuers.
(iii) Revision of insurable value with insurers.
(iv) Updating of records.

IV— ERECTION OF NEW STRUCTURES AND ALTERATIONS

(i) Construction plans (use of architects).
(ii) Securing of necessary permits.
(iii) Implementation, e.g. by outside contractors.
(iv) Monitoring progress.

V—SALES OF LAND AND BUILDINGS

(i) Recommendations to sell
(ii) Decision to sell.
(iii) Selling methods.
LAND: Selected readings for more study


CHAPTER VI

BUILDINGS
BUILDINGS

Training Objectives

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

1. Explain the importance of planning adequately for building location.
2. Apply the principles of a proactive approach.
3. Explain why a lack of space could be the consequence of other problems rather than only a problem in itself.
4. Use the Systematic Layout Planning method.
5. Specify when it is advantageous to rent premises.
6. Know the contents of building records.
7. Plan and examine critically storage areas.
8. Mention many security measures appropriate for buildings.
9. Define the purposes of maintenance.
11. Determine how to implement a maintenance programme.
12. Explain the economics of preventive maintenance.
BUILDINGS

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6.97 Conclusion 259

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This material should be covered in two sessions. If there is some time left at the end of the second session, it is suggested to spend additional time on relating clearly all maintenance aspects covered in this chapter with those in Chapter III.
CHAPTER VI
BUILDINGS

6.111 Introduction and Planning: The topic "Buildings" includes a wide range of sub-topics which represent interesting managerial challenges. How should the location and layout of buildings be planned? How is it possible to improve the efficiency of storage areas? What considerations should prevail for maintenance? These are some of the issues that will be discussed in this chapter. Outline procedures have been provided at the end of the preceding chapter.

6.112 A building is a physical structure in which activities are performed. The nature of the activities is varied, but so are the types of buildings where operations of organizations such as RDIs are performed.

What types of buildings exist in your RDI? Are these buildings suitable for the activities which take place in them?

6.121 Planning: Many of the older buildings visited during fieldwork were either too small or congested due to the limited amount of land on which they were built. These buildings generally appeared to be unsuitable in light of the current requirements.

Why is this the case?

6.122 In fact, operations of RDIs often outgrow the buildings and land they occupy. Because facilities get overcrowded, operations become less
efficient. At one point, adding personnel might even reduce the overall productivity of an RDI! This observation is illustrated in Figure 6.1.

Figure 6.1. Impact of too Important Increases in Personnel on Productivity

![Image of a circular diagram illustrating the impact of personnel increase on productivity and overcrowded facilities.]

6.123(a) Although the construction or leasing of each building could well have been planned with a specific purpose in mind, the nature of the projects undertaken in RDIs often changes over time. Consequently, buildings have a tendency to become less and less suitable, resulting in operations less efficient than before.

6.123(b) The changes in the nature or size of the operations of an RDI do not happen overnight, which makes it difficult to perceive their usually negative impact on the adequateness of buildings. Only a periodical re-examination of the suitability of buildings in light of the present and future activities of the RDI could help alleviate this problem, by allowing the efforts of the personnel to be oriented in the proper direction.

6.124 Decisions regarding the type and location of buildings should be known a few years ahead of the construction and be in line with the long-term plan of the RDI. However, in practice, these decisions are sometimes taken only when the urgency for more space arises.

Give some thought to this reasoning. Do you agree or not? Why?

This is an important cause explaining why buildings often become less suitable than before. Few persons realize its impact. Has the nature of the projects changed in your RDI? If so, how has it changed?

This is an important cause explaining why buildings often become less suitable than before. Few persons realize its impact. Has the nature of the projects changed in your RDI? If so, how has it changed?

What is the long-term plan of your RDI, in terms of operations? In terms of buildings?
6.125 **Specific Purposes:** Before more space is required, it is necessary to evaluate the utilization of the existing space. Adding space without seriously considering all causes for this situation, simply postpones existing problems such as a too wide range of projects, a poor layout, and inefficient materials management.

6.126 Planning for a suitable location and for an appropriate layout takes time and is best done ahead of time rather than in a rush. The location of existing buildings cannot be changed and neither will be the location of planned buildings, once the structure will be erected. Decisions such as this one represent future operating constraints. In fact, to acquire or rent a building without sufficient planning does not only illustrate poor planning in this area but also indicates that other areas might suffer from the same problem.

6.127(a) Planning for new structures should be a continuous exercise, even when funds may not be immediately available. It is likely that RDIs which experience growth will need other buildings. Knowing the level of growth of a specific RDI makes it possible to compute when the buildings will be required.

6.127(b) Therefore, there are no valid reasons to justify delaying the planning exercise, considering that government officials will require plans anyway for the location and layout of the building, if it has to be constructed. Such authorities might even ask for the intended location of buildings at the time of the acquisition of land. Whether they follow-up on the actual location and use is another matter.

6.128 The considerations above do not imply that plans regarding buildings cannot be changed, but rather that it is much easier and more efficient to adapt them than to leave all plans until they are needed for approval. Modifications to plans imply that managers have gone through the planning exercise, are already aware of the current and future needs of the RDI, and have taken sufficient time to understand the implications of each option. For example, if the dimensions of the land acquired differ from those of the land initially acquired, explain the impact of these 3 aspects on space requirements.

6.126 Draw a diagram of the location of your RDI buildings below. Immediately below this diagram, draw another one showing how you would locate the buildings now, if you could change their location on the existing piece of land.
considered, it might be necessary to change only the location of the buildings originally planned, so that they can accommodate planned future expansion.

6.131 Planning Sequence: Appropriate planning reduces the likelihood of costly mistakes. One important planning mistake to avoid is to modify the logical sequence necessary to get adequate buildings. The proactive approach suggests to select land, based on the RDI equipment and nature of operations. This is preferable to using a reactive approach, which might force managers to adapt building requirements to the land granted or purchased. The difference between both approaches can be seen on Figure 6.2.

6.132 Circumstances do not always permit the use of a proactive approach. For example, managers of an urban RDI with little land still available are facing a more difficult situation than managers of a large agro-research RDI with most of the land still available. However, managers of an urban RDI with a recent building should have planned a possible upward expansion, by having the building structure built accordingly.

Is this approach much easier than planning for new structures only when these are required?

In your own words, define "proactive approach" and "reactive approach". Provide 2 specific examples where a reactive approach was used. How would it have been possible to use a proactive approach?

Example #1
Reactive:

Proactive:

Example #2
Reactive:

Proactive:

Figure 6.2. A Reactive vs a Proactive Approach in Land Selection

LAND

BUILDINGS

EQUIPMENT

LAND

BUILDINGS

EQUIPMENT

Reactive approach

Proactive approach
6.133 Whatever the sequence of steps used for planning, procedures to obtain necessary authorizations are necessary. It is also necessary to ensure that RDI managers are dealing with duly authorized personnel or with the owners. Fieldwork revealed that clear policies did not always exist in planning new buildings; when they did exist, they were not necessarily followed strictly, as evidenced by the tendering procedures used as compared with the written procedures.

6.134 Planning for buildings does not only include construction, but also disposal, whether buildings are demolished or surrendered to another entity. Since disposal of buildings is a relatively rare occurrence and involves the policy-making body of an RDI, overall guidelines might be sufficient, instead of detailed procedures.

6.14 The plans of an RDI are normally reflected in its budget. Five-year budgets include costs of intended buildings and equipment. These capital costs also bring maintenance and repair costs, which should be reflected in each subsequent annual budget. It is not justified to make capital acquisitions if their value and condition go down more rapidly than would be the case with proper maintenance. In other words, maintenance and capital costs should live or die together.

6.151 Size of Buildings: Top RDI managers have an important role to play in the determination of the size of planned buildings. Their decisions will limit the scope of the operations for a long period to come, although better decisions in areas such as layout might provide some flexibility.

6.152 There is a tendency for organizations to occupy all the space available to them, whatever the nature of their operations and the size of the premises. This observation also applies to RDIs. Thus, it is not surprising that RDIs need more and more space: efficiently-run RDIs might have no other option, while others simply use this option because it appears that adding space will solve their problems.

Case #6.1: In an RDI centered on coffee, there are procedures on the steps required to obtain proper authorizations for new buildings. Despite these procedures, the Board directly authorized the construction of an extension to a building because most of it was a Board Room and the Chairman's Office.

In your RDI, are maintenance expenditures planned at the same time as capital expenditures?

What do you think about this observation? Think also about other organizations to confirm if it applies or not to most organizations.
6.153 If funds are available and managers convinced that a new building is required, then it is advisable to build larger than smaller, particularly if the growth rate of the RDI is high. This suggestion is based on the so-called "60% rule". The rule states that doubling the capacity costs only 60% more, not 100%, as would be expected. This is an empirically based rule, verified in a variety of situations. For instance, if the addition of 200 square metres costs $20,000, the addition of 400 square metres would cost $32,000 rather than $40,000. The $32,000 is computed as follows: [$20,000 + 60%($20,000)].

6.161(a) Nature of the Operations: It might be preferable to isolate certain RDI activities from other activities for reasons such as safety, secrecy or the necessity for researchers not to be disturbed. In such circumstances, a building is set aside, away from other buildings, whether it is located on the same RDI land or many kilometres away.

6.161(b) This approach also has the advantage to locate activities in potentially less costly premises, an interesting perspective for urban RDIs. Additional coordination costs might well be compensated many times by the savings and by the other advantages already mentioned.

6.162 An appropriate layout is another way to isolate certain operations from others. It can also contribute substantially to the efficiency of the operations of an RDI.

6.21 Definition: A layout is a disposition of people, machines and furniture in order to make planned activities possible. To choose a layout is not just simply to decide where each department will be situated, but also how they will be arranged in an orderly fashion making possible efficient operations.

6.221 Layouts are modified daily. The impact of these modifications are seldom examined, especially when changes appear to be minor. However, after some time, the cumulative impact of all those changes is being felt. Most persons might have noticed a reduction of efficiency, while only a few know some of the reasons for that situation.
6.222 Well-planned layouts take staff preferences into consideration, when it is reasonable to do so. A pleasant layout improves staff satisfaction, although it does not necessarily increase their productivity.

6.223 As the nature of the operations of an RDI changes, even imperceptibly, so does the layout. Unfortunately, both types of changes are not necessarily made in conjunction one with another. As a consequence, the layout partly becomes a hindrance to efficient operations, while it should be a flexible way to adapt buildings to the changing requirements of an organization over time.

6.224 To examine the layout of a portion of a department or all of it, or even the layout of the entire RDI, might improve operations substantially. This is not surprising, because there is a clear relationship between layout and productivity. Some modifications might be quite easy to determine, while others might require many weeks of data collection and careful analysis.

6.225 Layout changes should be considered only with a holistic view, e.g. by taking into account the impact of the proposed changes on the efficiency of the whole department, and even of the entire organization. It is suggested that layouts be re-examined with such an approach on a regular basis not exceeding three years. The period suggested should be shorter for R&Ds experiencing a high growth level or changes in the nature of some of their operations.

6.226 Relationships Among Departments: It is preferable to put departments with closely related operations and whose members have frequent contacts, close to one another. For instance, if expensive equipment should be shared, grouping user departments makes sense. Similarly, the main warehouse is usually situated close to the receiving department.

6.227 When planning a layout or a relayout, it is essential to take the views of research scientists and other users into consideration. As they are the
ones who will occupy the premises, it is only reasonable that they be given a chance to express themselves.

6.233 One of the main purposes for placing some departments close to one another, is to try to minimize distances travelled by people or materials. These operations are essentially unproductive, making a reduction in their number or importance highly desirable.

6.234(a) Many computer programmes on layouts are available. Some can even take into consideration constraints such as the necessary proximity of some departments or the location of equipment which it is preferable not to move. No programme provides an optimal solution, because of the extremely large number of possible combinations.

6.234(b) The collection of data on distances is usually a burdensome task. It might be justified in circumstances where substantial savings are thought to be possible. However, it is sometimes possible to collect just enough data to be positive enough about its validity. The reader interested in the computation of confidence intervals for such data can read any book on time and motions studies or on statistics.

6.235 The most useful method for planning a layout is called Systematic Layout Planning or SLP (Muther), and can be done without a computer. It does not require quantitative data collection, but only to determine the importance of the proximity of each department with each of the others. Qualitative factors can be given a larger importance when comes the time of the final selection. Example 6.1 and Exercise 6.2 represent SLP applications.

To do an exercise on SLP allows to analyse the relationships among departments. For those working in different RDIs, ask questions about the layouts obtained: an examination by outside observers is often useful.

To what extent has this aspect been taken into consideration in your RDI?
Example 6.1: Systematic layout planning

Situation:

It is necessary to plan a layout for an existing building, with dimensions of 40 metres by 50 metres.

Solution:

(1) Determine the relationship chart to represent desirable and undesirable closeness among departments

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Area sq ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Biology dept.</td>
<td>2</td>
<td>A</td>
<td>I</td>
<td>U</td>
<td>U</td>
<td>500</td>
</tr>
<tr>
<td>2. Sampling dept.</td>
<td>3</td>
<td>I</td>
<td>O</td>
<td>U</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>3. Receiving dept.</td>
<td>4</td>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>4. Administration</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>200</td>
</tr>
<tr>
<td>5. Communication dept.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>300</td>
</tr>
</tbody>
</table>

Legend for closeness:

- A = Absolutely important
- I = Important
- O = Indifferent
- U = Undesirable

(2) Make a relationship diagram

[Diagram showing the layout of the building with dimensions and department locations]
Exercise 6.2: Systematic layout planning

Situation:

Assuming that an RDI with the following relationships among departments has to be moved into an existing building of 40 metres by 50 metres, what layout would you suggest?

<table>
<thead>
<tr>
<th>From</th>
<th>To 2</th>
<th>To 3</th>
<th>To 4</th>
<th>To 5</th>
<th>Area sq m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stores</td>
<td>O</td>
<td>A</td>
<td>A</td>
<td>I</td>
<td>400</td>
</tr>
<tr>
<td>2. Accounting dept.</td>
<td>O</td>
<td>O</td>
<td>I</td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>3. Laboratory</td>
<td></td>
<td>A</td>
<td>O</td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>4. Process dept.</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>500</td>
</tr>
<tr>
<td>5. Receiving dept.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>300</td>
</tr>
</tbody>
</table>

Solution

The relationship chart is already determined. The following steps are to make a relationship diagram and to propose a layout.

Relationship Diagram

1

2

3

4

5

Proposed Layout

Do NOT read on unless you want to compare your solution with ours. Please note that more than one layout is a valid solution, as long as it uses the relationship diagram.

OUR Relationship Diagram

OUR Layout
6.241 **Limitations:** Layout modifications can sometimes be expensive. This is the case when a piece of equipment cannot be installed without moving other equipment and demolishing walls. However, if proper planning has been done, these consequences were known at the time of acquisition, and appropriate measures will be taken to limit the delays.

6.242(a) Although a layout gives some flexibility in the use of a building, it does not compensate for all existing problems such as overcrowded buildings. Impressive efforts might well be made to improve the efficiency of operations through better layouts, but there comes a point where other options than only layout changes should be examined.

6.242(b) One such option—not necessarily the best one—is to acquire extra space by building or renting additional premises, keeping in mind that a specific building is suitable for only a limited range of activities. Furthermore, extra space should imply a re-examination of the existing layout to determine if improvements not thought about or not made previously would be appropriate.

6.243 Existing facilities represent a major constraint for modifications to the present layout. For instance, receiving docks usually cannot be moved as easily as administrative offices. Consequently, they are very seldom moved. This is quite a different scenario than planning receiving docks in a building not yet constructed. In such advantageous conditions, there are many possible options, although the necessary proximity of some departments might limit the number of good options to five or six.

6.244 Rented premises usually represent bigger constraints than buildings owned by an RDI. Landlords, including governments, often restrict the scope of the modifications that can be carried out in the rented building, in order to be able to use or to rent these premises subsequently, without incurring substantial modification costs.

*Mention some of the existing limitations in your RDI.*

Case #6.2: A large RDI had such problems with office space that the majority of personnel had to work in small stores or where animals were being bred.

Case #6.3: In an RDI from another country, some of the labs were so squeezed that even microscopes had a hard time finding space to rest!
6.31 **Project Management:** Although contractors and architects are responsible for erecting buildings and adhering to construction standards and municipal regulations, RDI managers should control the operations. They must make sure that procedures established by funding agencies are adhered to.

6.32 Clear instructions on steps to be followed are necessary, even when low cost or temporary structures are built by RDI staff. Written general guidelines are indicated in this case.

6.33 Control is possible mostly through discussions with contractors and architects, and by comparison of actual work progress with plans. A variety of planning and control techniques exist. The most useful ones are described in the manual for Series I, *Strategic and Project Planning, and Budgeting,* and include CPM and Gantt chart.

6.34 It should not be forgotten that planning and control are very closely related. As a consequence, thorough planning can only be supported by proper control. Similarly, strong controls are justified mostly when there has been adequate planning.

6.351 Let us consider two examples illustrating the importance of proper planning and control. First, there should be enough time planned to get all mandatory authorizations from local and national governments. Somebody should be responsible to do the follow-up on these requests, many of which being necessary before the project could even start.

6.352 Second, to move operations from one building to another — or even within the same building — can be a painful and costly experience. However, very detailed planning and subsequent control could alleviate substantially the number and importance of problems incurred. This is true whether the building is the RDI's property or not.

6.411 **Major Reasons for Renting Premises:** Ownership does not necessarily constitute a better solution than renting, although it provides more flexibility with layouts.

*It could be appropriate to examine briefly these 2 techniques in Series I Manual.*

*Could control be considered as an "after-the-fact planning"? (Note: Think twice before you answer!)*
6.412 When an RDI has space problems, renting might represent an interesting option. A lease extends the time period available to managers before selecting land suitable for the RDI operations. It is preferable not to rush into making a final selection, mostly because of the costly consequences of an inadequate choice.

6.413 Office space is usually available in urban areas. This offers an alternative to locate departments which can as well be away from the main RDI premises.

6.414 Rented space might well be the only possibility to locate downtown. If this is the case, the time frame considered for the lease should be rather long than short.

6.415 When it is necessary to rent, it should be remembered that leases are the result of a negotiation between two parties. Landlords might be ready to make important concessions for reasons such as having vacant premises occupied, signing a long-term lease or leasing to a prestigious tenant. RDI managers could take full advantage of favourable conditions by assessing properly the situation before undertaking any discussion. One of the most advantageous clauses is to get many renewal options, to be exercised if the tenant wishes to do so.

6.421 Constraints in Renting: The nature and scope of the activities to be performed, the location (district) preferred, and the lease period wanted, place severe constraints on the number of suitable locations. A clear and brief description of the type of location looked for should help to reduce rapidly the number of locations. It is also advisable to ask some personnel likely to use the premises, to assess the suitability of such property.

6.422 Substantial costs might sometimes be incurred directly or indirectly to adapt the rented premises in order to suit the specific requirements of the RDI. Incurring these costs is justified mostly if the lease obtained is a long-term lease.

6.423 If there is little space available in the area, the rent might be higher than what would

How much office space availability is there in the area where your RDI is?

If your RDI occupies rented premises—at least in part—what type of concessions did it get from the landlord?
normally be justified. The situation is similar if the lease offered to the RDI is then a short term lease, while a long-term one was looked for: it might be necessary to move again shortly, or to incur a high rent increase.

6.424 Owners do not always make all maintenance and repairs they should do, as quickly as they should, assuming it would eventually get done. Therefore, it is sometimes necessary for the RDI to incur such costs.

6.51 Documentation: Proper documentation with regard to buildings is a critical need. Fieldwork made obvious that documentation clearly identifying the various buildings and other structures in RDIs was either defective or non-existent. So, despite the little time required to update such documentation — when it is available — efforts were put in areas perceived as more important. For some RDIs, it is only managers' unawareness which created this situation. It is advisable that heads of RDIs should ensure that records and other relevant documents be available for inspection.

6.521 In case any past information on buildings is required to make decisions, proper documentation provides written evidence of it. It is inappropriate to use only peoples memory or to run the risk that the persons who could provide the information work no more for the RDI. In some cases, it is possible that decision-makers do not even know who could be aware of such information!

6.522(a) Documentation on buildings is useful for at least two reasons. First, it could be used to make proper decisions regarding maintenance activities. If this information is not available, it is not possible to know which activities have been performed, and when they have been performed.

6.522(b) Second, it provides all details about the unique name or number of each building, its exact location, the date or dates of construction, the blueprints, the building layout, modifications made to the structure or to other portions of it such as the roof, special features, security status and

Case #6.4:
An RDI in Malawi occupies buildings owned by the Ministry of Works and Supplies. When it takes too long to have repairs done by the Ministry, these are made by the RDI's own staff or by external contractors, on funds from the RDI.

This looks like a lot of information, doesn't it? Try to justify for each element why it could be useful to have the information available.
other security information, etc. Accordingly, whenever an information about buildings is required, it would be easy to get it.

6.53 Top managers should make the decision as to what information is necessary and what documentation will be kept. They are the ones who need most of this information in the first place, even when it comes to establish maintenance policies. They should not fall into the trap of wanting all possible information, but rather define their needs. If proper documentation is not updated or not available, and it is known that it might be required at a later date, it will likely be more costly to obtain it then.

6.54 Accordingly, once it is decided that a type of information is required, it should get put together by the Estate Officer or his personnel. This person should be responsible not only for keeping information updated, but also for storing building documentation in a safe place. If there is nobody responsible for these activities, they will not be performed properly, assuming they get done at all.

6.55 Building Identification: A fully comprehensive system of identification of buildings (and rooms within such buildings) is required particularly in those RDIs with extensive administrative and residential buildings. Rented as well as owned buildings should be identified.

6.56 There are many reasons why it is preferable to identify clearly all temporary and permanent buildings. Each reason makes sense on an individual basis; when put together, they could push managers to have the identification job done within a week! The main advantages are related to:

- Easiness of identification by outsiders and staff;
- Maintenance and repair jobs and documentation;
- Insurance coverage;
- Safety of personnel and safety procedures;
- Identification of equipment;
- Authorizations for extensions to buildings.
6.571 All logical systems of identification may be used. The key factors are the easiness of the system for the users, and the possibility to modify layouts or add buildings without having to modify substantially the identification numbers already in use.

6.572 One system consists in identifying buildings by letters, floors by consecutive numbers and rooms by numbers. For example room B-519 could be in the biology building, on the 5th floor, the 19th door from the main entrance. Other systems could be as effective. Exercise 6.3 allows you to test your understanding of numbering systems.

**Exercise 6.3: Identification of rooms**

**Situation:**

The following layout is the 4th floor of a meteorological centre situated in a 4-storey building (called the “information building”). This centre also occupies another 2-storey building. The 4th floor is used for administrative purposes only. How would you number the rooms in a systematic manner?

Do NOT read on unless you want to compare your solution with ours.

**Solution:**

Our solution is the following:

- F = I-401
- E = I-402
- F = I-403
- B = I-404
- C = I-404A
- D = I-405
- I = I-411
- K = I-412
- G = I-413
- H = No number
- J = I-412A

Try to justify our numbering; it is often necessary to understand numberings made by others!
6.611 Storage Areas: The lack of storage space and the inappropriateness of the management of storage areas constitute acute problems for RDI managers. Operations efficiency of an RDI is directly influenced by the situation prevailing in the stores. Space is costly, it is only when managers and staff are convinced of this reality, that it becomes possible to look for solutions to space problems. Thus, storage space management should not be considered of secondary importance.

6.612 The following observations were made in many RDIs visited during fieldwork:

- Poor storage facilities;
- Poor recording systems, especially in terms of custody of records;
- Random location and layout;
- Many insecure storage points;
- Inadequately trained staff to manage and operate storage points.

6.613 Inadequate storage space is not only a problem, but also often a symptom. The funny thing about storage space is that it represents an interesting similarity with personnel: always more is needed, never less! As a consequence, inadequate storage space should not be accepted at face value without scrutinizing the situation.

6.614 Thinking of storage space as a symptom presents the situation under a new light. To scrutinize this situation is a challenging exercise which could contribute to identify the causes looked for, and help to pinpoint to suitable solutions. An outside consultant might be brought in to assist RDI managers and stores staff in doing so. The specific characteristics of an RDI also play an important role in making interesting solutions more or less likely.

6.621 Planning Storage Areas: Storage space does not simply happen: it is created. This can be done haphazardly, with obvious results. However, storage areas can also be planned properly, whether for new buildings or existing ones.
6.622 It is important to plan for enough storage space as soon as possible because, later, priority for available space is given to other activities. When space is rare, it appears difficult to do otherwise, considering that stores have only a supporting role for the main activities of an RDI. There are even instances where already insufficient storage space is reduced because of the support role of stores!

6.623 Furthermore, when insufficient space is initially allocated to storage areas, it becomes difficult to integrate these areas properly later. Subsequent layout changes involving stores are indeed less and less likely, with the result that operations are not as efficient as they could be.

6.624 The number of stores depends on the nature of the items to be stored, on the total space available and on the extent of control required. For instance, to plan only for one store is indicated for small RDIs and for RDIs with a small number of users. On the other hand, a separate storage area would be preferable for dangerous goods.

6.625 Storage areas should be planned with very specific purposes in mind. For example, store A is for spare parts, store B for materials, etc. Stores are not just places where to put anything; in other words, storage areas are not simply storage space for documents, furniture, equipment, materials and spare parts placed in a disorderly fashion. Naturally, this is the way it looks like when items that should be kept separately, are not.

6.631 Content of Stores: Appropriate control over what goes into the stores constitutes a good step to reduce storage space required. Undesirable items — old files, broken equipment, etc. — should not be accepted at all, if the area is for materials only. If little control exists over the determination of items to be stored, there will be no limit to storage space required. Orderly storage would become impossible, resulting in more bad feelings about the messiness of stores.

What is your opinion about the location of stores in your RDI?

Would this approach of having different stores for different types of items make sense in your RDI? Why?
6.632 Basically, storage space exists to stock materials and other items that are not immediately required, but for which a clear need has been identified. For example, spare parts aim at reducing the delay during which a piece of equipment is out of order.

6.633 At least once a year, a review of the content of all stores should be made, to identify obsolete materials and all other items which should be disposed of. For items for which it is appropriate, a tag could indicate the date until which each item should be stored.

6.641 Storage in Other Premises: Usually, storage areas are thought about as being in the buildings where the other activities of the institute take place. This conception should be expanded to include other premises.

6.642 Rented premises can be used as additional storage space, as long as they are suitable for the intended purpose. Buildings for storage purposes do not have the same characteristics as those appropriate for performing administrative tasks. For instance, they could have more secure foundations, do not require many windows, and could be cheaper to rent due to their location.

6.643 If buildings are used for storage purposes when they were not intended for it, it is likely that they will not be used efficiently. During fieldwork, it was noted that some residential houses had been used as stores. This should be done under exceptional circumstances, and for a short period of time only.

6.644 Such a situation could arise when suppliers offer interesting quantity discounts, while there is not enough storage capacity in the RDI. From an economical point of view, it might be advantageous to incur additional renting and transportation costs. However, it should be asked in the first place if better materials management (which includes stores) would not have made renting outside premises unnecessary.

6.651 Other Considerations: Storage bins could save much space, if they are assembled to allow

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Is it done? If not, how useful would it be?

Why would this be?
the safe use of the height of storage rooms. Using bins would make it easier not only to set but also to code and identify items.

6.652 Safety in storage areas is important. It is addressed in the next section.

6.711 Importance of Security: Security aims at protecting persons or objects from known risks. Managers may want to reduce the likelihood of occurrence of some clearly undesirable events. Their decision is based in part on economics, but also on other considerations such as reducing hazards and the potential loss of human lives.

6.712 Although security is a critical issue, due to the nature of the operations of RDIs, strangers could enter relatively easily into many RDI buildings. This observation was applicable even for RDIs where there were dangerous materials and processes, costly materials or equipment and controlled or secret (or about) experiments. Generally-speaking, it is preferable to restrict access to all or specified premises, to authorized personnel only.

6.713 A security code from 1 to 5 could be attributed to each building. Different codes could be used for different parts of the same building, because it might be justified to have extremely tight security procedures in one part of a building, and fewer in another part of it.

6.714 The first decision to be made is to define what are the risks that managers want to protect the RDI from. Then, the consequence of these risks is evaluated, and the options examined. Finally, a decision is made, considering the tradeoffs involved.

6.715 Some aspects of building security are closely related to land security. For instance, a fenced land with guarded gates should reduce dramatically the number of unwanted outsiders. Other procedures already mentioned in the preceding chapter include getting proper authorization from an RDI manager and wearing a badge.
Locks, barred windows and alarm systems constitute specific ways to prevent intruders from getting into buildings. Some of these systems or devices are expensive, but could sometimes be justified.

Some procedures could also be very useful in improving security measures:

- Buildings with a few doors only;
- Avoidance of congestion of stores;
- Escort of visitors to the institute's premises;
- Proper lighting;
- Limited access to personnel during off-duty hours.

Specific Places: Storage areas, especially when congested or when items are stacked too high or improperly, create special hazards for persons working therein. These dangerous conditions should be eliminated rapidly by proper stacking or by disposing of items stored unnecessarily.

Researchers sometimes use materials or prepare chemical solutions which should be stored in controlled-temperature conditions. If costly or hazardous conditions could result from equipment malfunction, the proper operation of such equipment should be checked on a regular basis.

It is also preferable to isolate from other areas, laboratories using dangerous chemicals or making biological experiments which might be harmful to humans. The same applies to storage areas in regard to hazardous chemicals. When it is impossible to isolate such areas, they should at least be clearly identified.

Rented premises should be given the same level of security as other RDI premises do get under similar circumstances. It could even be argued that procedures should be reinforced for rented premises, because of the proximity of many outsiders. This is particularly the case when only a portion of a building is leased.
6.731 **Prevention:** Security is more related to prevention than to correction. No RDI manager is interested in the occurrence of any of the hazards he is trying to prevent. Most of the times, problems created by such undesirable occurrences are not only costly financially, but also in terms of lost productive time, when it is not in terms of injuries or deaths. It is obvious that no insurance coverage is adequate to cover this reality, which could be even worse if facilities are overcrowded.

6.732 Annual premium costs are usually much lower than the cost of incidents covered. When insurance coverage is available and affordable, it should be seriously considered for all hazards, including theft and fire.

6.741 **Fire Protection:** Fire usually represents a much more important hazard than theft. A quick response time by designated staff, or by voluntary or professional firemen, can reduce damages substantially. In fact, knowledge about what to do and prompt action reduce the importance of most hazards. This is why personnel trained to face such circumstances represent an important asset for an RDI.

6.742(a) Adequate provisions for fire-fighting should be included in designing and building all types of structures. For instance, adequate design should allow a sufficient number of doors.

6.742(b) All personnel should know at least the number to call or the person to tell, and where the emergency exits are. Some should know how to operate internal fire-fighting equipment, although fire-fighting and other emergencies should be put into the hands of especially-trained people such as firemen, as quickly as possible.

6.743 Clear and well-understood procedures and responsibilities are necessary in order to improve security. For instance, fire drills are useful to ensure that people will have the proper reactions should there be a fire.

6.744 Fire-fighting equipment and procedures should be appropriate for all types of fire hazard. For example, an extinguisher suitable for a wood
fire is not necessarily appropriate for an electric fire, although there is a type of extinguisher which can be used for both types of fire. At any rate, their location should be well indicated.

6.745 It is necessary to inspect regularly — usually at least three times a year — all firefighting equipment, to ensure that it is in the proper location and operational. If required, unusable equipment should be fixed rapidly. It should be remembered that the piece of equipment needed the next time might be the one left in an unusable condition...

6.746 In some RDIs, it might be justified to install smoke detectors and/or sprinkler systems. Sometimes, suitable systems or adequate operating conditions do not make it possible. However, the choice often boils down to a tradeoff between the costs and risks involved.

6.811 Purpose of Maintenance: Buildings tend to deteriorate over time. Equipment fails, often without giving notice. Such facilities are used because they make operations run more efficiently, and fit their intended purpose only when RDI staff experience no problems with them. To wait that problems occur constitutes a reactive approach. However, it is possible to have a more proactive attitude, by trying to prevent most of the problems before they take place.

6.812 Definition: Maintenance is an activity aimed at reducing the deterioration of buildings and the number and importance of equipment failures. It limits the problems that managers have to face when there are difficulties with the existing facilities.

6.821 Importance of Maintenance: When managers wait for problems to occur, they are likely to face more problems than when planned maintenance is performed. In fact, proper maintenance reduces the number and severity of failures, and may provide substantial economies. Details will be provided in a few pages.
6.822  Maintenance is like health care: a little negligence is not too harmful, while complete negligence will likely result in severe problems. Proper health care does not eliminate all health problems, neither does maintenance in regard to failures.

What do you think of this comparison?

If maintenance does not eliminate failures, what can be done to eliminate them?

6.823  Although maintenance as such is an unproductive activity, it improves the productive use of facilities. When managers simply wait that problems happen, they live with much more uncertainty and potential problems hanging over their heads, than when planned maintenance is performed. Unplanned disruptions of activities are more likely to happen in the first case than in the second.

If no assessment of the state of buildings is done in your RDI, check the appropriate reasons below:

<table>
<thead>
<tr>
<th>Reason</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignorance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negligence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other priorities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of funds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.824  Despite these considerations, maintenance of buildings was not considered a high priority in the RDIs visited. There were no regular building inspection exercises to assess the state of buildings in order to determine when minor repairs and other forms of maintenance should be carried out. Actually, in most cases, the tendency was to wait until a problem developed and made it necessary to undertake the repair work.

6.825  The approach just described is inappropriate in most situations: the longer the delays before proper maintenance and repairs, the more costly repairs will be. Although this observation is true both for buildings and equipment, building maintenance suffer most due to the fact that buildings deteriorate more slowly and seldom make it impossible for staff to work. For example, it might be as important to repair a leaky roof as a leaky motor, but it is possible that the latter will be repaired first, because the machine is used more often.

6.826  Too little preventive maintenance is costly not only for an individual RDI, but also for the whole nation. It is indeed government authorities who grant most of RDI funding.

Case #6.5:
An agricultural RDI was not allowed to enter into maintenance contracts with other companies, because all
are not used as well as they could. Budgets play a major role in this regard.

6.831 **Maintenance Budgets:** It is therefore imperative that all those who allocate and approve budgets be convinced that there are significant advantages in favour of proper maintenance. There are two ways to reach this objective: first, by explaining the advantages of planned maintenance; second, by showing figures illustrating how much money could have been saved. Both avenues might be useful.

6.832 When funds are tighter than ever, it usually gets more difficult to justify the use of funds for preventive maintenance. Accordingly, unless managers are convinced of its importance, maintenance could well be reduced to generate some “savings”. Only major repairs could get done, not only because they would be necessary in practice, but also because it would be obvious to all those who authorize expenditures, that they have little choice in voting the required amounts.

6.833 There should be a clearly-identified budget heading entitled “Repairs and Maintenance- Buildings”. Those who authorize budgets should insist on obtaining the breakdown of expenses between these two areas; top ROI managers could sometimes even request the details within each. This is a good way to ensure that a detailed maintenance programme supports the budget figure.

6.834 There are two other advantages in doing so: it is less tempting to use the funds for other purposes, and it emphasizes the importance that top managers devote to maintenance. In fact, the amounts devoted to preventive maintenance are often a good indication as to whether the approach used by management is mostly short-term or long-term oriented.

6.841 **Compensating for Past Policies:** It is normal to expect that new buildings require less maintenance than older ones, but they do need maintenance. Otherwise, they will get to the point where more and more repairs are necessary.

**Is this done in your RDI?**

Based on your observations, is the amount of money allocated for maintenance sufficient in your RDI?
The extent of maintenance can be reduced by the use of high quality materials and by the adherence to tough standards for the construction of buildings. The initial cost would then be higher, but it could be recovered in subsequent years. This tradeoff is an interesting one between incurring a low known cost now, and incurring a potentially higher cost later. This situation is similar to the tradeoff between known maintenance costs now, and potentially higher repair costs later, as shown on Figure 6.3.

Figure 6.3. Reaching an Equilibrium Between Maintenance and Repair Costs

It should be obvious by now that a large portion of present repair costs is due directly to too low maintenance costs incurred in the past. Therefore, annual maintenance costs lower than optimal maintenance costs represent a liability for the future; only its timing is uncertain. Furthermore, most repair costs to be incurred increase over the years. Conversely, close to optimal maintenance costs in a given year provide benefits which extend over that specific year, as can be seen in Figure 6.4.
Then, what should be done presently about deteriorated buildings for which maintenance, and even repairs, have been largely ignored? A rehabilitation programme should be worked out showing for each building, the extent of deterioration, materials required to renovate or rehabilitate the building, labour required, other costs, and an appropriate work schedule since all buildings may not be renovated at once.

Such a programme should also indicate where contractors could be used and where internal staff could do the job. If certain materials have to be imported, the sources, prices and periods required for the materials to arrive should also be stated. As can be seen, this represents a major project. It is advisable to hire professional advisors to support staff in doing this job.

Would this programme be useful for your RDI? If so, how much time could it take to rehabilitate all buildings? (Be reasonable!)
requiring much technical competency. Proper records for buildings should make the job easier, if they are available and up-to-date.

6.846 The costs incurred for such an evaluation are justified, because they are necessary in order to make sound decisions. However, the funds required for the rehabilitation of the buildings are much higher, and it should be determined what portions of the proposed programme are going to be adhered to. If the original intent at the time of study was to accept only a small portion of the expected modifications, then the study was not justified in the first place.

6.847 Finally, it should be noted that it is preferable to ear-mark special funds for the rehabilitation programme. Otherwise they might not be available when time comes to use them.

6.851 Responsibilities: There is no accountability without responsibility. Maintenance is more likely to get done if there is one person responsible for it. Depending on the size of the RDI, it is suggested that an officer be designated for maintenance of buildings and equipment. This manager could also be responsible for land, and could be referred to as Estate Officer. It is usually inappropriate to assign such duties to the general manager, because of the wide array of tasks he has to perform.

6.852(a) The Estate Officer is responsible for the maintenance crew, when there is one. It is very costly to have an internal crew, without ever having to call in a contractor. This could indeed indicate that the crew is too large or the maintenance backlog, high. Why? In the first instance, the size of the crew acts as a buffer for the variations in maintenance and repair work to be done. In the second case, the buffer is time.

6.852(b) The choice between an internal maintenance crew and contractors — or of a combination thereof — depends on factors such as the size of the RDI, the number and competence of contractors, the severity of potential problems, job specialization within the internal crew, response time and cost. Usually, contractors are the ones

This is a key idea in management. Think about at least one situation in your RDI, where clear responsibilities would improve that situation.

Is there a maintenance crew in your RDI? Is it too large, too small, or of the appropriate size?

Are contractors used in your RDI for some maintenance jobs? For which type of jobs?
performing minor repairs when the internal crew is overwhelmed, and most major repair jobs.

6.853  Proper maintenance is difficult without the support of all personnel. Everybody should collaborate by advising the Estate Officer when a deterioration is noticed or when a piece of equipment is not operating properly. It is more likely that personnel will collaborate when it is obvious that top management strongly endorse preventive maintenance, and the repairs done within a reasonable time.

6.861  The Economics of Preventive Maintenance: Although safety and sanitary factors are sometimes sufficient to justify preventive maintenance, economical factors are an important consideration.

6.862  The tradeoff between preventive maintenance and repairs is based on the following reasoning. When very little or no maintenance is performed, the cost of repairs is high. On the opposite, nearly exaggerated preventive maintenance would result in very few repairs. Both extreme solutions are usually not the most appropriate for an organization. In the first case, more maintenance reduces significantly the cost of repairs, while in the second case maintenance has become more costly than repairs. Thus an intermediate position seems indicated. This situation is represented in Figure 6.5. Further explanations have also been provided in Chapter III.

6.863  It could be argued that this is only a mathematical model. It is indeed. But a model is a representation of reality under certain assumptions. In this case, the only assumptions are the shape of each curve. Whatever the exact figures, the reasoning mentioned above still applies.
6.864 From an economical standpoint, there is an optimal maintenance figure. However, looking at the figure reveals that the immediate area on both sides of the optimal point is nearly flat. Consequently, it does not make a big difference whether a little more or a little less preventive maintenance than optimal is done. Both theory and practice show that, costwise, it is preferable to perform more than less.

6.865 The exact timing of preventive maintenance is slightly less important for buildings than for equipment, because they have a longer useful life, and are less subject to abusive operating conditions.

6.866 However, both types of facilities require sufficient data collection to enable decision makers to be sure enough about the value of their decisions. If repair costs have been collected before, the task should be easier than otherwise. It is indeed a difficult task to estimate future repair costs when there is no sound basis to justify these estimates. Maintenance costs include salaries, planned repairs, materials, and unproductive personnel time.

This observation is essential for all situations which can be represented with the type of graph above. Why is it preferable to do more than less from a cost standpoint? (Clue: Look at the graph.)
6.871 **Maintenance Planning:** Planning building maintenance aims at limiting interference with RDI regular activities, while doing appropriate inspections and repairs.

6.872 It is sometimes possible to postpone some minor repairs for a short period of time, without incurring additional costs. This allows for planned maintenance and repairs. For instance, if window frames are due for inspection in a month's time, it might be worth it to delay the repair to one frame by one month also, because some other frames might need similar repairs.

6.873 It might be appropriate to perform a maintenance task ahead of time. The replacement of both tap washers when one only is not working properly is a frequent maintenance policy which illustrates this point.

6.874 Inspections are performed to identify visually or with instruments if facilities need repairs, and if so, when the repairs are needed. The frequency of building inspection is based even more on judgement and experience than it is the case for equipment. In the latter case, there are indeed manufacturer manuals on suggested maintenance policies.

6.875 Judgement does not mean that inspections can be done only at convenient times, but that it should be based on a set of factors. Such factors include age of building or parts thereof such as the roof, type of structure, major sources of problems, unusual climatic conditions, etc.

6.876 All inspections require a checklist and should be documented. It is not necessary to inspect all items on the checklist every time, because their frequency of inspection might be different.

6.877 Finally, planning the activities of major planned (in time) maintenance projects imply more coordination of resources. PERT/CPM and Gantt bar charts might be valuable techniques for the planning of this type of activity.

Do you agree with this type of approach?

What would you include as part of the building preventive maintenance programme for your RDI? Would you perform some of these steps only after inspection?

Are there any major planned maintenance projects? Provide an example if you think so.
6.91 **Valuation:** It is often heard that buildings should be evaluated on a regular basis, usually no more than every three to four years. To establish such a policy does not guarantee that it will be followed, particularly if the reasons for the policy are obscure.

6.92 The valuation process usually requires little time from RDI personnel when professional appraisers are hired. They make the necessary analyses, defining clearly their valuation basis.

6.93 Building valuation is clearly not a priority in RDIs. Daily and strategic preoccupations prevail, unless arises a major reason for doing or getting a valuation. The weight of the following reasons might differ depending upon the circumstances applicable to a specific RDI. For instance, because buildings in urban RDIs usually appreciate more than their equivalent in rural RDIs, managers of RDIs in cities may want to get a building valuation more often.

6.94 Buildings constitute very important assets of RDIs which own them. Thus it appears justified to perform a regular valuation for reporting and insurance purposes in order to reflect market value and determine replacement cost. It should be noted that the actual cost usually appears in the financial statements, the market value being provided as an additional information.

6.95 Knowing the market value puts into perspective the importance of proper maintenance and repair policies. It also provides a basis of comparison for national planners to evaluate the relative importance of the activities taking place in different RDIs, and the value of the investment. To do so, similar figures for land and equipment are also required.

6.96 Finally, valuation provides an amount upon which to base discussions for the sale or purchase of a building. In a similar vein, the market value also allows to establish the reasonableness of economic costs paid in the vicinity.

How is it possible to get all activities done, without neglecting any of them, including building valuation?

Case #6.6: One Kenyan RDI treats all buildings as expenditure at the time of construction. This is done purely for accounting purposes.
6.97 Conclusion: The key aspects covered in this chapter on buildings were location planning, layout, storage areas, safety and maintenance. All these aspects are obviously closely related to similar aspects in the other chapters. Overall, it appears that building management is much neglected, probably because the consequence of that negligence does not show up as rapidly as it does for equipment.

6.98 Proper management of buildings offers an opportunity to improve the efficiency of RDI operations. So do improved management of equipment, materials and land. Results do not come by themselves. It is only through concerted efforts aimed at RDI effectiveness and efficiency that RDIs can really contribute to national development.

6.99 Live now the Facilities and Materials management approach mentioned in this manual, remembering that:

"Improvement Today Is Better than Perfection Tomorrow."

Look at the contents of each chapter on the third page of each of these chapters. List all topics and identify those which come more than once. This illustrates how related the areas of facilities and materials management really are!

In summary, what are the 3 key aspects of facilities and materials management that you would suggest to examine in order to improve significantly your RDI’s operations? Be specific.

(1) __________________________
(2) __________________________
(3) __________________________
BUILDINGS: Selected readings for more study


MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D INSTITUTE FACILITIES AND MATERIALS MANAGEMENT

GLOSSARY
ABC analysis: The ABC principle corresponds to divide a group of items into groups, in order to allocate efforts accordingly. Class A receives the most attention because it includes the items with the highest annual dollar volume; B is the medium class, and C includes the lowest annual dollar volume items.

Board of Survey: A group of individuals chosen by RDI or government authorities, to decide upon the disposal of equipment and materials.

Budgeting: The process of anticipating the financial requirements for R&D.

Building: A physical structure in which activities are performed.

Controlling: The process of making adjustments which correct for the deviations from planned progress.

Corrective maintenance: Refers to carrying out a repair, replacement, or complete overhaul of a piece of equipment only when it breaks down.

Dependent demand: A quantity which is directly determined by another quantity. When the demand for an end item is known, then the demand for the component items is dependent because it is also known.

Disposal: The act of getting rid of an item or of a piece of equipment by selling it, scrapping it, or by giving it in exchange for a new one.

Distribution of failures: A graphical or arithmetical representation of the frequency of failures over time.

Double-bin system: This system consists in separating the quantity used before the reorder point is reached from the quantity used once the order will have been placed. A replenishment quantity is ordered when the first bin is empty.

Economic order quantity (EOQ): It is a type of fixed order quantity method, which determines the optimal quantity to order, considering ordering costs and inventory holding costs.

Effectiveness: It usually means that a person, thing, or process actually accomplishes intended results. Therefore, resources are being used while aiming at the proper objectives.
Efficiency: It implies both speed of execution and parsimony in the expenditure of money and other resources, as compared to plans.

Equipment: Consists of all fixed assets other than land and buildings.

Facilities: All physical resources built, constructed or installed, and which are necessary to operate.

Failure: Condition caused by a break, with the result that an element can no longer fulfil its purpose.

FIFO: It is a method of inventory valuation where the oldest inventory (First In) is the first to be used (First Out).

Fixed order quantity: An inventory control where the size of the order is fixed, but the time interval between orders depends on actual demand.

Fixed-period model: Periodic reordering system where the time interval between orders is fixed but the size of the order vary according to usage since the last review.

Gantt chart: It is a type of bar chart depicting the work planned and done in relation to time.

Holding costs: All costs directly identifiable to the decision to hold inventories. These costs are usually defined as a percentage of the dollar value of inventory per unit of time.

Independent demand: Demand for an item is considered independent when it is unrelated to the demand for other items, i.e. it is necessary to estimate the overall quantity needed in order to determine the quantity to be ordered.

Indirect costs: Those which are incurred by the RDI but which are not directly attributable to the requirements of projects.

Inventory: Quantities of unused materials owned by an organization and which are usually stored until their use.

Inventory stocktaking: A procedure which allows to count all items on hand at a specific date.

Just-in-time: A philosophy aimed at substantially reducing inventories by ordering only small quantities of items so that they arrive only at the moment they are required. The implication is that each operation is closely synchronized with purchasing.

Land: Surface of the earth and its natural resources.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layout</td>
<td>A disposition of people, machines and furniture in order to make planned activities possible and as efficient as possible.</td>
</tr>
<tr>
<td>Lead time</td>
<td>The period from a user's requisition to the satisfaction of the need.</td>
</tr>
<tr>
<td>Life cycle concept approach</td>
<td>This approach considers the following costs for the evaluation of equipment to be purchased: acquisition, installation, maintenance, and operating costs. Other quantitative factors such as expected useful life, resale value and cost for major overhauls are also considered.</td>
</tr>
<tr>
<td>LIFO</td>
<td>It is a method of inventory evaluation. The most recently received inventory (Last In) is the first to be used (First Out).</td>
</tr>
<tr>
<td>Maintenance</td>
<td>It is an activity aimed at reducing the deterioration of buildings and the number and importance of equipment failures.</td>
</tr>
<tr>
<td>Maintenance management</td>
<td>The function of providing policy guidance regarding the nature, scope and frequency of preventive maintenance, taking into consideration an equilibrium with the costs of corrective maintenance. It also includes the review of existing maintenance programmes.</td>
</tr>
<tr>
<td>Materials</td>
<td>Items and substances which can be considered as inventories once they are acquired.</td>
</tr>
<tr>
<td>Materials requirements planning (MRP)</td>
<td>A set of techniques which uses bills of material, inventory data and the operations schedule to calculate requirements for materials. This approach is used mostly when there is a dependent demand. It aims at ordering the right quantity at the right time.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Observing project progress and resource utilization, and anticipating deviations from planned expectations.</td>
</tr>
<tr>
<td>National development</td>
<td>The process that ensures the most equitable positive change in these factors, for all elements of society.</td>
</tr>
<tr>
<td>National development plan</td>
<td>An aggregate of sectoral and often regional plans that specify government development strategies for a given period of time.</td>
</tr>
<tr>
<td>Operations</td>
<td>The actual conduct of the research and development activity in an RDI, a term used to distinguish the act of conducting R&amp;D from that of planning.</td>
</tr>
<tr>
<td>Ordering costs</td>
<td>All costs which are identifiable with placing an order. These include costs related to the clerical work of preparing.</td>
</tr>
</tbody>
</table>
issuing, following and receiving orders, the physical handling and inspection of goods.

Organizing: An action to structure relationships among personnel, financial and material resources, in order to accomplish a specific set of objectives.

Overhead costs: The cost of staying in business; the cost of running the RDI.

Pareto’s law: This law says that 20% of the items under study usually account for 80% of the occurrences that are of interest. It is similar to the ABC classification.

PERT: (Programme Evaluation and Review Technique). It is a project planning technique for defining, integrating and interrelating what must be done to accomplish a desired objective on time.

Planning: Setting appropriate objectives for R&D work, then selecting courses of action which are most likely to result in effective fulfillment of them. It is the process of making decisions about what is to be done; why; for whom; how; by whom; with what resources; and when?

Preventive maintenance: A procedure of inspecting a system at regular intervals according to specific instructions, and intended to prevent failures in service or to reduce deterioration.

Proactive management: An approach which puts the emphasis on planning and acting accordingly.

Probability: A number which estimates the percentage of times that a particular result would occur. This number can be a subjective guess or it can be based upon empirical results.

Procedures: Approved methods of administrative operations.

Procurement: This term, is wider than purchasing: It also includes stores, traffic, receiving, incoming inspection and salvage.

Project planning: Focuses on R&D projects; generates specific project objectives, tasks, resources requirements and schedules.

Project proposal: A statement of justification for the objectives, methods, resources and management of an R&D project.

Purchasing: It is the process of buying. The basic activities of purchasing include, among other things, checking the specification of materials which are requisitioned, buying the materials
which represent the best value for the purpose intended, selecting sources of supply and negotiating with suppliers.

**R&D:**
An investigative and adaptive process using a wide range of methods for deriving and applying knowledge to enhance national development.

**R&D management:**
The efficient and effective planning, 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.

**R&D plan:**
A logical statement of the sequence of events leading to the accomplishment of specific technical objectives.

**Reactive management:**
An approach, which puts the emphasis on solving problems when they occur, as opposed to the approach used in proactive management.

**Reliability:**
The probability that a component part, equipment, or system will satisfactorily perform its intended function under given circumstances.

**Reorder point:**
It is a quantity of items on hand which, when it is reached, signals that it is necessary to place an order for a pre-specified quantity, so that the service level already determined be adhered to. This point is normally calculated as: forecasted usage during the replenishment lead time plus safety stock.

**Researchers:**
Research managers who are primarily responsible for the output of the RDI, through: (1) bringing specialized technology to bear on the resolution of national development problems; (2) proposing, conducting and reporting the result of research projects; and, (3) furthering the technical productivity and capability of the RDI.

**Research 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 on priority national development problems.

**Resources:**
A group of elements which makes it possible to operate, namely people, money, land, buildings, equipment, and materials.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Running-in period</td>
<td>A period of time during which mechanical and electronic components of equipment begin to be used.</td>
</tr>
<tr>
<td>Safety stock</td>
<td>Additional quantities that are in stock to protect against stockouts due to unpredictable fluctuations in demand or in lead times.</td>
</tr>
<tr>
<td>Sampling plan</td>
<td>Is composed of two elements, namely the sample size and the limit number of defects tolerated in the sample in order to accept the entire lot, based on the sample inspected.</td>
</tr>
<tr>
<td>Selection criteria</td>
<td>Factors used as a basis to compare all options.</td>
</tr>
<tr>
<td>Service contract</td>
<td>A contract that is made between the buyer and supplier to repair or to provide maintenance after the purchase has been made.</td>
</tr>
<tr>
<td>Service level</td>
<td>The percentage of demand that is satisfied within a specified time.</td>
</tr>
<tr>
<td>Simulation</td>
<td>The technique of utilizing representative or artificial data to reproduce an actual situation in order to make decisions.</td>
</tr>
<tr>
<td>Spot check</td>
<td>This procedure is similar to inventory stocktaking, with the difference that it is performed on an irregular basis and for a limited number of items.</td>
</tr>
<tr>
<td>Standardization</td>
<td>The process of designing and/or reviewing products to establish and use standard specifications for them and/or components. One of the goals of standardization is to reduce the number of items involved.</td>
</tr>
<tr>
<td>Stock records</td>
<td>A ledger card that contains inventory status for a given item.</td>
</tr>
<tr>
<td>Storage area</td>
<td>A site where equipment, materials, work-in-process, or other items are held until they are needed.</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>Focuses on RDI goals, scope of R&amp;D activities, and RDI resources, establishes the relationship between RDI mission and national development goals, frequently serves as a basis for RDI policy development.</td>
</tr>
<tr>
<td>Supplies</td>
<td>Materials which are not directly necessary to the transformation process. For instance, oil and nails are supplies.</td>
</tr>
<tr>
<td>Support staff</td>
<td>Those research managers who are primarily responsible for supporting strategic and research activities by: (1) collecting, combining, analyzing and interpreting information on all institute operations; (2) converting institute policies to</td>
</tr>
</tbody>
</table>
management systems, and (3) facilitating the relationship between institute policy makers and researchers.

**Stockout:** It is the lack of materials or components which are needed, but are not in stock.

**Systematic layout planning:** Technique of layout to obtain the best disposition according to qualitative factors that may be crucial to the placement decision. The technique requires the creation of a relationship chart showing the degree of importance of having each department located adjacent to every other department.

**Technology:** A set of equipment, know-how and procedures making possible the mastering of the way to achieve specific desired results.

**Tradeoff:** A giving up of one benefit, advantage in order to gain another regarded as more desirable.

**Valuation:** Estimation done by a professional appraiser, regarding the value of an object.

**Weighted average cost method:** It is an averaging technique where the data to be averaged are not uniformly weighted. It is a mean in which the relative importance of each item is taken into consideration in the computation.

**Zero inventory method:** A philosophy of manufacturing based on planned elimination of all waste and on consistent improvement of productivity.
MANAGEMENT MANUAL FOR PRODUCTIVE R&D: R&D INSTITUTE FACILITIES AND MATERIALS MANAGEMENT

GENERAL BIBLIOGRAPHY
General Bibliography


Good overview of warehouse management. Covers warehousing from its origin to today's operations. Very extensive, useful for the beginner and the professional.


Determining the costs included in EOQ and how they are determined, is not as easy as it could appear.


Mostly economics of urban land. A simple model of agricultural rent and land use. Does not deal with valuation per se.


Practices recommended by a majority of professionals in the procurement sector. Quite general. Also includes discussions on ethical point of view.


As purchasing activities deal with large amounts of money, getting aware of and acting upon purchasing costs is a way to improve profits. A good coverage of planning, forecasting, negotiation, value analysis, relations with suppliers, control of purchases and measurement of purchasing performance.


Some useful aspects for the manager. Chapters 6 and 7 provide a good overview of physical storage and stores operations; chapter 9 and following covers inventory management.


Contains considerations and techniques useful to determine a purchasing policy. Considers economical and managerial point of view.

Tables for “Order Quantity” and for “Reorder Point Safety Stock”.


Economics of land valuation. Very complete on the following aspects: factors determining supply and demand for land; economic principles affecting use of land resources; impact of institutions on land use and property; issues associated with social direction of land use.


Land use produces two things: products (agriculture) and fertile lands (asset for the future). Discusses the idea of “social vs personal” use of land. In French.

Bartholomew, Dean. “Block Counting to Achieve Inventory Record Accuracy”. *P&IM Review*; August, 1984: 40-42.

Discusses the concept of block counting. Where cycle-counting can’t be used, block counting could be a substitute.


Examines the applications of cycle counting and how such a system should be designed.


As purchasing becomes a more and more important function, it is relevant to see that the purchasing manager must play an active role in corporate strategy and planning.


Overview of procurement activities and policies. Very general. In French.

A very good book on different ways to improve procurement operations by taking a proactive approach rather than a reactive approach. Easy to read, and could be quite useful.


A review of resources and financial opportunities for investment, including land acquisition.


How to apply the ABC method to cycle-counting, provides an example.


Covers many topics, ranging from quality, costs, and negotiations to inventory control and warehousing. It is general, but covers the areas of interest in this manual.


This is a good article for RDIs whose managers want to keep their systems simple. It examines five techniques of inventory control (ABC, EOQ, 2 bins, inventory control cards, Min and Max). Although it is based on the actual case of a small US manufacturer, the concepts are useful to RDIs and shown in a practical context.


A very interesting discussion on maintenance management. It explains how maintenance is a key function to make JIT work properly, but many of these aspects are appropriate in most situations. It also covers the influence of maintenance labour, plant equipment and spare parts inventory thereon.


How to determine a procurement strategy, based on procurement scope, supplier selection, pricing and negotiation. This strategy should be implemented properly in the organization. Case studies are interesting and could be useful, due to their empirical nature.

Good overview of procurement procedures and of equipment and materials considerations before making a purchase.


Suppliers are key information owners and could be turned into partners.


Algorithm to help prevent the shortage of maintenance spare parts. Shows that it could be useful for developing countries also.


Basics on research of supplier for substitutes, avoidance of shortages, and determination of what a fair price is.


Good description of the ABC method and of the appropriate steps for its implementation and control. Determination of savings that this method can provide.


Chapters 6 to 11 cover inventory management. This book is one of the best in terms of clarity.


General overview and basic definitions of those systems and of Zero Inventories. Very concise, but clear.


One of the most comprehensive texts on the topic. Provides all details about sampling plans and process control.

Necessity of an annual physical inventory could be eliminated with a proper cyclecounting inventory procedure, aimed at reducing costs of inventory stocktaking.


How to perform inspection based on statistical quality control for attributes (good or no good) and variables (measurements such as weight).


Applying JIT philosophy to the interface between operations planning and purchasing. A close look at the impact of JIT on purchasing.


47 guidelines to prepare a negotiation. The message is clear: "The negotiator who is best prepared invariably wins"!


Mathematical model to allocate land for several uses. Could be useful for RDIs with computer facilities and which need to allocate land. Quite esoteric, although it could be useful in some cases.


An international overview of traditional types of land control: the feudalistic lord and tenants system of Asia; the feudal large farms type of Latin America; the communal ownership of tribal groups in Africa; private ownership; collective ownership, and the plantation or ranch type. Position of the World Bank on the issues raised. Good to see social implications of these forms of land ownership.

Focuses on the distinctions between the acquisition of services and of equipment. Although it results from a survey of US companies, this article points out clearly to the impact of those differences on the organization.


First chapters describe quality, its basis and how to perform a test. Recognized by many as the basic textbook on the topic of quality.


The purchasing function is changing to become an important contributor to organizational objectives.


An interesting manager's handbook with practical decision guidelines. Good appendices for evaluating procurement work.


Emphasis on price quality, and quantity considerations in the acquisition of materials and equipment. Also covers foreign buying, purchasing strategy, computerization, supplier selection and many others. Complete and recent with case studies. Very practical.


A make-or-buy situation is often perceived as an either-or choice. However, there are many other options between the 100% make and 100% buy. This gray zone is often forgotten by decision-makers, while it could improve the decision-making process.


The rural agricultural model in Africa. Production systems and farm administration. Examples from many African countries.

Private lands are important productive assets in Asia and Africa. Their effect on rural poverty is discussed, and some examples from India are given.


Organization, planning, budgeting and control aspects are covered in this book. Chapter 5 is dedicated to preventive maintenance.


Inventory objectives should be determined according to a service level objective, in order to make them reliable and suitable to the needs of the organization. A good discussion on the topic.


Elementary guide on cooperative shop buildings and equipment. Location, construction and other related topics.


A text directly oriented to Third World countries. A training aid package designed to assist cooperatives of developing countries in performing procurement and materials management in a suitable way.


The author presents the concept of the least total cost of procurement, together with the description of the three most common lot sizing rules.


Overview of international purchasing, the problems encountered, savings it provides. Questions to answer before implementation and steps on how to perform it well.

Discusses ways to improve purchasing performance on price, workload, efficiency, material flow, costs, vendor performance, and many other materials management aspects.


A very short and clear summary of the first computer applications to make in the purchasing department. Applications include highly repetitive work and purchasing department evaluation.


Use of a microcomputer in a purchasing department. Continues the discussion in the above article.


Provides a thorough examination of all aspects of purchasing.


A book which discusses all aspects of maintenance: organization, basic systems, types of maintenance, costs, planning, scheduling, measurement, motivation, control, and others.


Maintenance activities have a cost. This article presents an MRP-style system which makes tradeoffs among costs easier.


A thorough coverage of operations management. Includes chapters on technology, equipment, inventory management, MRP, procurement, quality, JIT, the determination of an operations strategy, and productivity. In French.

Could be useful especially for RDIs buying in foreign countries. Covers price determination, purchasing power, exchange rates, price level and price movement.


An overview on the evolution of land use in OECD countries. Tendencies and problems relevant to the situation. In French.


A good view of all aspects of maintenance management. It covers maintenance and maintainability from planning to corrective actions, cost analysis, design, process and many other considerations.


Chapters 2, 3 and 8 constitute a good coverage on inventory management and lot sizing.


Good discussion on reasons to hold—or not—inventories, considering their many costs.


Very good overview of maintenance management. Chapter on paperwork really shows the usefulness of records to plan effective maintenance operations.


As organizations in the public sector usually have to work with a different approach of service, it is these authors opinion that it is normal that their inventory differs in consequence. The authors present cost analysis procedures for the public sector.

A thematic book covering all maintenance activities. Suggests very practical and detailed steps to perform several maintenance tasks.


The effects of JIT philosophy applied to procurement.


A discussion on the Life Cycle Concept Approach.


Methods to determine optimum or near-optimum lot sizes with quantity discounts.