Minicomputers and Microcomputers in Engineering and Manufacture

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with contributions from

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Preface

Computers have enormous potential for improving the efficiency and competitiveness of industrial companies if professionally applied. This is the case whether the computer is a dedicated microchip integrated into a measuring instrument, a personal computer, minicomputer or a mainframe.

However, many companies have held back from grasping the opportunities presented by the computer. Many others have embraced computers but without the professionalism, understanding of the real needs of the application and detailed attention to system design essential for their successful use.

This book provides the basic principles of a systematic approach to the design of a computer application and focusses mainly on the needs of the application as distinct from the technical intricacies of the computer itself. It is, therefore, a book for users of computers as distinct from computer designers.

The book is directed towards the engineer and manager who wish to educate themselves in a modern systems approach for applying computers effectively in manufacturing companies. It is in many respects as much a book about the principles of manufacturing systems engineering as it is about computers and their application. This breadth of view is essential if computer systems are to be properly used to create competitive advantage and improve the overall performance of manufacturing companies. Also, there is clear evidence of the need for new types of manufacturing system to meet the needs of the 1980s' and 1990s' competitive markets, and this book aims to provide supporting modern integrated systems design methods.

The hardware and software of computer systems have reduced steadily in cost whilst increasing markedly in capability in recent

years, leading to many opportunities for their wider use which yet often are not realised.

One reason for missed opportunities or applications of computers which fail to provide expected economic advantages lies in an organisational problem in many companies, where data processing departments within a financial control function have traditionally been responsible for computer applications and operations. This tradition relates to the days when computers were large and very expensive and primarily carried out financial and commercial data processing activities. As opportunities have opened up in the past ten years for their effective use in manufacturing process and engineering applications these often had very expensive but ineffective computer systems applied to them, simply because data processing department personnel did not understand the engineering of products and manufacturing processes and the way manufacturing activities are best organised when computers are integrated. There is now no longer any reason for this limited approach to the use of computers in industry. Indeed it is now accepted that to make wide distributed use of the lost cost, highly capable equipment now available, the engineering profession, in particular the new generalist manufacturing systems engineer supported by the business systems engineer, has now to take the lead in designing effective computer applications. Such applications require the integration of expertise in computer systems engineering with an understanding of the following:

Business strategy.
Product engineering.
Process engineering.
Production engineering.
Systems analysis.
Control engineering theory.
Financial control.
Theory of organisation design.

To ensure broad and authoritative coverage based on wide experience, in structuring and writing this book I have enlisted help from expert colleagues in several industrial companies. These colleagues provided draft material which, with some editing and in some cases small additions of material and case studies, resulted in the following main allocation of responsibilities:

Chapter 1: Professor J. Parnaby, Lucas Industries plc

Chapter 2: Mr. M. F. Hessey, Lucas Industries plc, and Professor J. Parnaby, Lucas Industries plc
Chapter 3: Dr. N. D. Burns, Unilever plc, Mr. M. F. Hessey, Lucas Industries plc, and Professor J. Parnaby, Lucas Industries plc
Chapter 4: Professor J. Parnaby, Lucas Industries plc
Chapter 5: Dr. N. D. Burns, Unilever plc, and Professor J. Parnaby, Lucas Industries plc
Chapter 6: Professor S. K. Bhattacharyya, Lucas Professor of Manufacturing Systems Engineering, University of Warwick, in collaboration with Computervision Inc.
Chapter 7: Dr. A. Larner, IBM (UK) Limited, Warwick
Chapter 8: Professor J. Parnaby, Lucas Industries plc

The computer is, of course, an integral part of information technology. This book emphasises the need to avoid taking an over-specialised approach to the industrial application of information technology if this is to create economic benefit. It is believed that such benefit will come as a result primarily of the actions of the generalist professional engineer who is properly literate in information technology, and not from highly specialist computer scientists and information technologists alone. To this end, some definitions of information technology related to alternative application areas are offered below.

In Chapter 1 the basic principles of the structured approach of manufacturing systems engineering is described, taking account of the overall needs of the business strategy and showing how more effective use of computers can be achieved if, simultaneously with their application, changes are made to the organisation and its information flow structure.

The following chapters then pick up and develop the principles governing applications of computers, with a wide use of illustrative case studies taken from real applications. These chapters relate either to important subsystems of the total computer-supported manufacturing system architecture covered in Chapter 1 or to particular groupings of supporting methodologies. Chapter 8, in particular, deals with the important topic of project management and application specification, activities often not well done in companies.

At every stage care has been taken to identify the important fundamental principles governing applications of computers to eliminate the risk of an overly empirical approach inadequately

based in understanding. Therefore, it is intended that the engineer reading this book is properly educated as well as being trained in computer applications. He should then be better able to give strong leadership to his supporting specialist technician staff of computer programmers and systems analysts. Engineers in operational roles such as industrial engineering should find the book useful in helping them make continuous improvements to installed computer systems under their control.

It is also believed that the book will form a basis for a core 1–2 year single subject programme in university engineering undergraduate degree courses and Master's degree courses.

In writing the book as a part-time extra-mural activity over a lengthy period in a hectic business life as Director of Manufacturing Technology for Lucas Industries, I have been most grateful for the long-suffering patience of my wife, Lillian, and children, Sue, Mark, Chris and Nick, who have every right to feel a little neglected. I am also very much indebted to Christine Latimer for her help in coordinating busy sub-authors and for typing the manuscript and preparing the figures. Finally, I am grateful to Dr. I. D. Nussey and Mr. J. Hughes of IBM (UK) Limited for providing me with source material for the Maintenance and CADCAM case studies in Chapter 4.

Many of the ideas in the book are a result of my previous ten years' experience as a University Professor of Manufacturing Systems Design, together with working experiences during my career in several industries.

John Parnaby
Birmingham, UK

Some Contextual Definitions of Information Technology – I.T.

There are several quite valid ways of defining I.T., depending upon which sector of industry it refers to, e.g.:

1. Information technology is a key component of systems engineering and is inextricably integrated with systems analysis, since it relates to the way in which information and data are used to aid decision making in the process of planning and control at micro and macro levels in a company.
2. Information technology provides a foundation for the way in which electronic subsystems, including microcomputers, minicomputers and mainframes, are designed and integrated into electronic communication systems equipment, with the development of associated software in order to meet a specification for performance given by a potential user to an I.T. equipment (including software) supplier.
3. Information technology covers the detailed design for manufacture of electronic equipment, including computing elements, the associated software, instrumentation, operating systems, test procedures, quality and performance standards and interfaces.
4. Information technology relates to the specification of the information flow requirements of business systems and manufacturing systems and the effective provision of these through the design, commissioning and operation of hardware and software for increased efficiency, economic gain and the improvement of competitive performance.
5. Information technology concerns the linking together of electromechanical equipment subsystems into an integrated system where the inputs and outputs of data between subsystems are properly matched and controlled by software to achieve a desired system performance specification.

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CHAPTER 1

General Introduction and Systems Engineering Overview

PROF. J. PARNABY
Lucas Industries plc

1.1 Computers and business strategy

We are concerned here primarily with the application of computers to improve the efficiency of a business by improving in some way a part of the *value added* chain for the manufacture of a product or series of products. They may be used also to reduce the *value-less added* activities in a business. These two terms can be defined as follows:

Value-less added activity: this is some activity which costs the supplier of the product money but for which his customer is not prepared to pay. Examples of value-less added activities are:

1. Use of progress-chasing staff whose job is to search for or chase materials on the shop floor and provide up-to-date information to guide production control decisions to compensate for poor systems of planning and control.
2. Use of inspectors to check that components and products have been manufactured accurately to specification.
3. Management of work-in-progress stocks.
4. Use of excessive layers of indirect labour and service overhead staff for information transmission and processing.
5. Use of overcomplex and confusing systems designs and procedures for operation by staff functions to provide information or monitor performance.

Value-added activity: activities in the manufacture of a product which progressively enhance the value of the original raw material to produce a product of perceived higher added value at the lowest cost. The machines, computers, processes, skills and technologies used in the manufacture of a product all should add value. Activities

such as skilful marketing can also be regarded as value-added activities in some industries.

Computers can be used in most areas where value is added and equally can often be used with advantage to eliminate value-less added activities, e.g. by the provision of accurate and timely information on the state of production without the necessity of using large, expensive clerical staffs.

We have, therefore, to remember to ensure that the use of computers supports the business strategy.

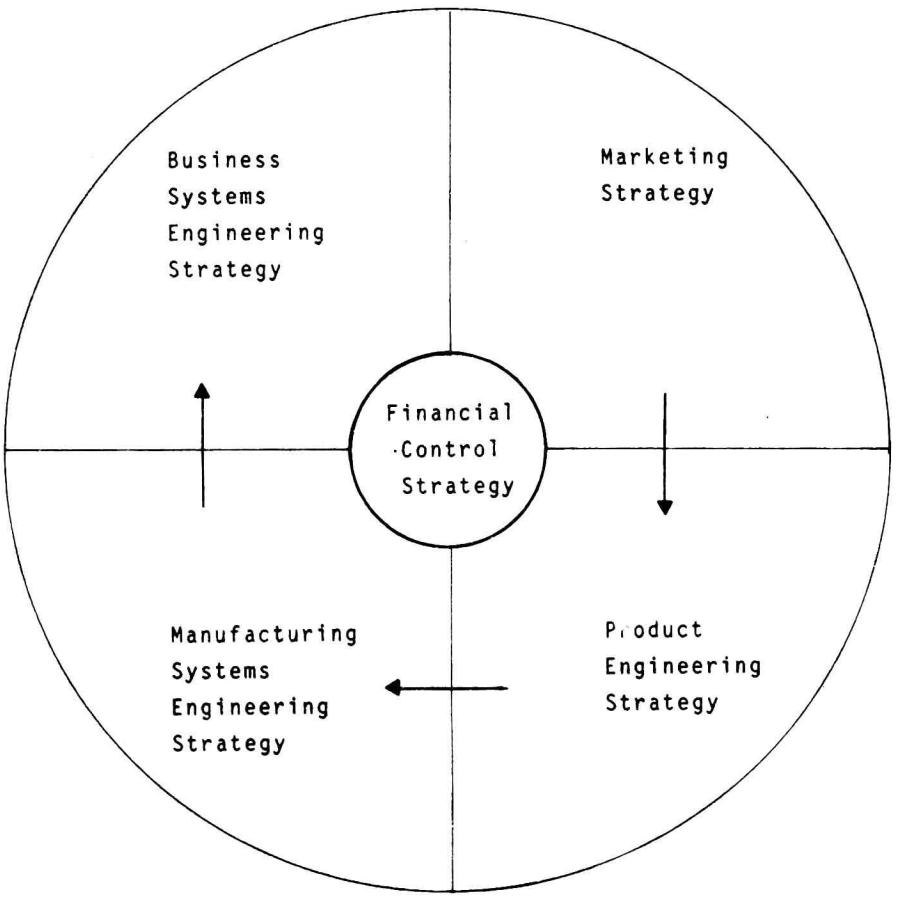

Fig. 1.1 Five key supporting elements of the business strategy.

The business strategy covers all areas of the business and must be detailed carefully to ensure that it aims at competitive performance. To focus this in relation to computer applications it is useful to consider the separate integrated and supporting segments of the business strategy, as shown in Fig. 1.1. For example, the manufacturing systems engineering strategy defines the nature of the equipment, processes and systems required to meet the particular product volume, variety, quality and delivery requirements of the market place of the particular business unit.

Some areas where applications of computers can improve the value-added activities in the five segments are:

Marketing strategy

- Production of market forecast curves.
- Storing databases of strength and weakness analyses against market segments.
- Supporting Pareto analyses of product costs and varieties, including competitors.
- Competitor value-added chain analysis.
- Information flows to and from other functions for communication.

Product engineering strategy

- Microprocessor chips built into products to enhance their function.
- Use of computer aided design and modelling systems.
- Storing materials property data and other technical databases for reference.
- Routine operation of standard calculation procedures.
- General information support for computer aided manufacture.

Manufacturing systems engineering strategy

- Databases of component specifications.
- Manufacturing route references.
- Work in process information.
- Provision of cutting dimension coordinate data to machine tools.
- Process control reference models and look-up table operations databases.
- Local area network information flow control.
- Provision of schedules for Kanban types of materials flow control system.
- Production engineering and tool management databases.
- Quality diagnostic support information.
- Maintenance engineering information.
- Equipment and process capability databases.

Financial control strategy
- Processing of accounts and payroll.
- Provision of product cost and value-added data.
- Provision of budget *vs.* actual reports to guide actions.
- Databases, e.g. plant, assets, pension funds, share register.

Business systems engineering strategy
- Office automation and word processing.
- Overall integrated planning of activities.
- Commercial information links between factories and suppliers or customers.
- Extraction of summary business control information from the other four areas.
- Parts and service information databases.
- Warehousing system management.

The important features to note are:

1. Well designed computer systems have potential impact everywhere.
2. The use of computers must be governed totally by the needs of the various strategies if they are not to increase value-less added activity.
3. A particular role of computer systems in all five strategic areas is that of the provision of information to support control functions or decision making functions.
4. Computers can help to integrate efficiently all the various specialised elements of the business strategy to create a coordinated approach without increasing value-less added activities.

1.2 Computer systems architecture – levels of control

There is a need for a structured set of guidelines to aid the choice and design of systems incorporating the application of computers. Without such guidelines, what should be a straightforward task for the various professional people associated with the five strategic sector areas becomes bewildering in its complexity. The result is an over-reliance on vendors or computer experts who often do not understand the application.

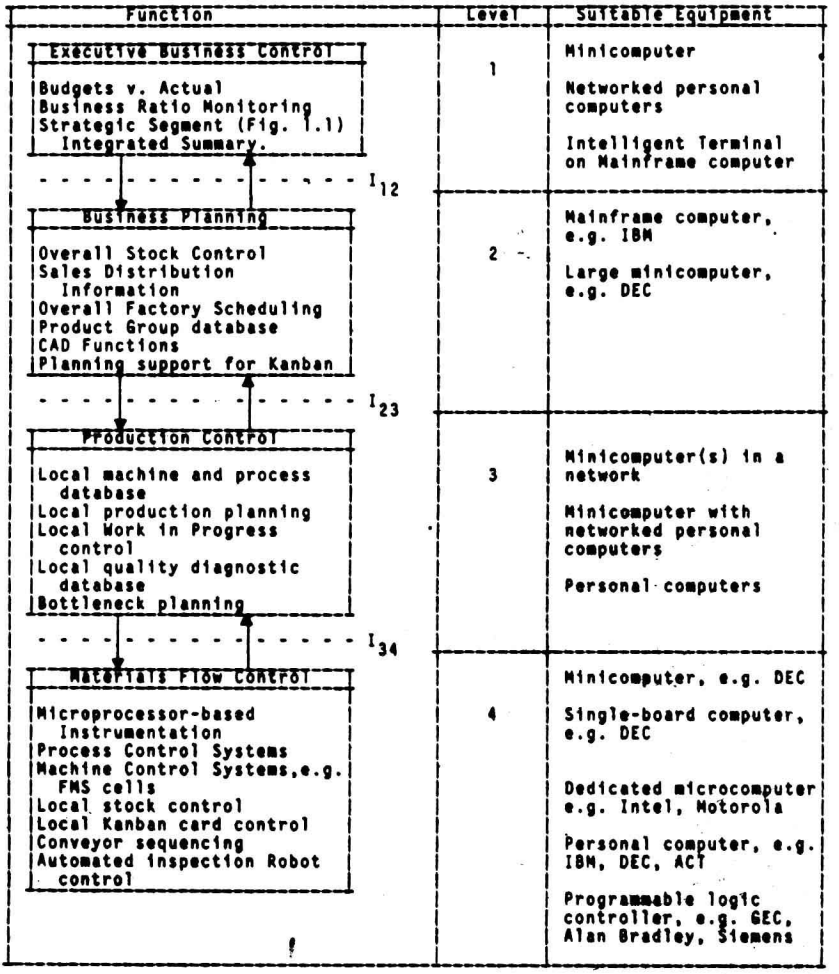

Fig. 1.2 Levels of control architecture – general system form.

The first important guidelines are those related to levels of operational control in a business, shown in conceptual form in Fig. 1.2. There are two particular features which create the need for such a design guide: