Shop Floor Control Systems

From design to implementation

Shop Floor Control Systems

From design to implementation

A. Bauer, R. Bowden, J. Browne, J. Duggan and G. Lyons

CHAPMAN & HALL
London · New York · Tokyo · Melbourne · Madras

UK	Chapman & Hall 2–6 Boundary Row, London SE1 8HN
USA	Van Nostrand Reinhold, 115 5th Avenue, New York NY 10003
Japan	Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 7F, 1–7–11 Hirakawa-cho, Chiyoda-ku, Tokyo 102
Australia	Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205
India	Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East, Madras 600 035

First edition 1991

Typeset in Great Britain by Cambridge University Press.

Printed in Great Britain by T. J. Press (Padstow) Ltd., Padstow, Cornwall.

ISBN 0 412 36040 3 0 442 31329 2 (USA)

British Library Cataloguing in Publication Data
Shop floor control systems.
1. Production management
I. Bauer, Alfred
658.5

ISBN 0–412–36040–3

Library Congress Cataloging-in-Publication Data
Shop floor control systems: from design to implementation / Alfred Bauer ... [*et al.*]. — 1st ed.
p. cm.
Includes bibliographical references and index.
ISBN 0–442–31329–2
1. Production control. I. Bauer, Alfred. 1956–
TS155.8.S47 1991 90–44087
670.42—dc20 CIP

ABOUT THE AUTHORS

Alfred Bauer

Alfred Bauer is a manager of advanced development working with CIM International Engineering of Digital Equipment GmbH in Munich. He is currently establishing a new engineering centre in Holland, Eindhoven focused on CIM and shop floor management systems. His previous activities during his ten years with Digital include hardware engineering, development of commercial systems, computer aided software engineering (CASE), technical consulting, and managing three ESPRIT projects in the area of CIM. Before joining Digital, Alfred worked for Texas Instruments on the development of test equipment for integrated circuits. He has publications in the field of production management systems, and is a member of various public committees such as ACM, IEEE, EuroPace, and the CIM-OSA Management Committee. Alfred has a diploma in Electronic Engineering.

Richard Bowden, PhD

Richard Bowden graduated with a BE in Industrial Engineering from University College Galway in 1985. He then went on to complete a Masters in Engineering Science in 1987 at the same University, in the area of software-based design tools for robot-based assembly systems. In 1987, he commenced his PhD studies in the area of shop floor control. Part of his PhD studies involved working with the advanced manufacturing engineering group in Digital Equipment Corporation in Clonmel, Ireland. This work involved the completion of a succesful pilot implementation of a shop floor control system in an electronics assembly environment, within Esprit project no. 477, as described in the latter part of this book. He completed his PhD in June 1990. He is now employed within the Advanced Systems and Technologies Group in Digital Equipment Corporation, Galway, Ireland.

Professor Jim Browne

Professor Jim Browne graduated with a PhD from the University of Manchester Institute of Science and Technology for work done in the area of digital simulation of manufacturing systems. He joined UCG in 1980 and was appointed Director of the CIM Research Unit in 1986. He is chairman of the Special Interest Group on Robotics in CIM Europe, is a member of the International Federation of Information Processing Technical Committee 5 and Working Group 5.7 on 'Production Planning and Control'. He is the author or co-author of in excess of eighty scientific papers, has edited a number of books and is co author of a book entitled *Production Management Strategies – A CIM Perspective*, published by Addison-Wesley in 1988.

James Duggan, PhD

James Duggan graduated in 1985 from University College Galway, with a BE degree in Industrial Engineering, and subsequenty completed a Masters of Engineering Science degree in 1987. During the course of his PhD studies at the CIM Research Unit, UCG, he worked closely with the management information systems group in Digital Equipment Corporation, Clonmel, Ireland. This work involved developing a prototype shop floor control software system, described in the latter stages of this book. He completed his PhD in June 1990, and is now employed within the advanced systems and technologies group at Digital Equipment Corporation, Galway, Ireland.

Gerard Lyons, PhD

Gerard Lyons is Manager of the information management group at the Digital Equipment Corporation manufacturing facility in Clonmel, Ireland. He is also responsible for the plant's CIM research work under the European Commission sponsored ESPRIT programme. His interests in the CIM area revolve around the impact of information technology on manufacturing systems, processes and organizations, and he was responsible for the pilot implementation of production planning and control systems described in this book. Gerard is an engineer by training and holds Bachelor's, Master's and PhD degrees, as well as being professionally qualified as a Chartered Engineer (CEng).

ACKNOWLEDGEMENTS

We acknowledge the insights we have gained from the many formal and informal discussions with colleagues from various European industries, universities, resarch institutes and the Commission of the European Community working within the Esprit and Esprit II programmes of the Economic Community. We acknowledge the financial support of the European community for much of the work discussed in this book. This support was delivered through the CIM (Computer Integrated Manufacturing) activity within ESPRIT. The authors worked together in ESPRIT project 477, entitled COSIMA (COntrol Systems for Integrated MAnufacturing). We are very grateful for the encouragement, fruitful discussions and many insights gained from our partners in COSIMA, Comau in Turin, Italy and Renault in Paris, France. We acknowledge in particular the support of M. Actis Dato and Franco Deregibus of COMAU, and Francois Feugier of Renault.

We thank our colleagues at Digital Equipment Corporation, especially Basil Cooney, Niall Connolly, John Harhen, Declan Kennedy, Manus Harley, John Lenihan, Bill O'Gorman, and James Shivnan. Within the Digital Equipment Corporation Clonmel plant, we acknowledge the financial support of the advanced manufacturing engineering group, particularly for our work on factory scheduling. We are also grateful to many people in the operations and manufacturing engineering groups for their interest in and support of our research activities, particularly Tom Malone, Paud Barry and Colin Linanne. Some of the ideas described in this book resulted from early work of the COSIMA project team in Digital Equipment Corporation Munich. In particular, we are in great debt to Hermann Konrad, Ora Jaervinen, Peggy Isakson, David Lane and Cathal Copas who have made special contributions through their dedicated work on the COSIMA project. We thank David Stone, Ernst Wellhoener, and Don Young for the management support they have given us over time.

We thank our colleagues within the Department of Industrial Engineering at University College Galway, in particular, Dr Ivan Gibson, Professor M.E.J. O'Kelly, Dr John Roche and Dr John Shiel. We are grateful to the Computer Services Group within UCG for their technical support in preparing the original manuscript.

A special thanks goes to our colleagues at the CIM Research Unit of University College Galway, particularly David O'Sullivan, Paul Higgins, Conor Morris, Sean Jackson, Una O'Connor, Michael McLoughlin, Allen Moran and Noel Fegan for their helpful criticism of the first draft of this book.

We thank Mark Hammond from Chapman and Hall for his continuing patience and help as the manuscript developed.

Finally we acknowledge the many authors whose work we have consulted in the preparation of this book and whom we have referenced in the manuscript.

PREFACE

In recent years there has been a tremendous upsurge of interest in manufacturing systems design and analysis. Large industrial companies have realized that their manufacturing facilities can be a source of tremendous opportunity if managed well or a huge corporate liability if managed poorly. In particular industrial managers have realized the potential of well designed and installed production planning and control systems. Manufacturing, in an environment of short product life cycles and increasing product diversity, looks to techniques such as manufacturing resource planning, Just In Time (JIT) and total quality control among others to meet the challenge.

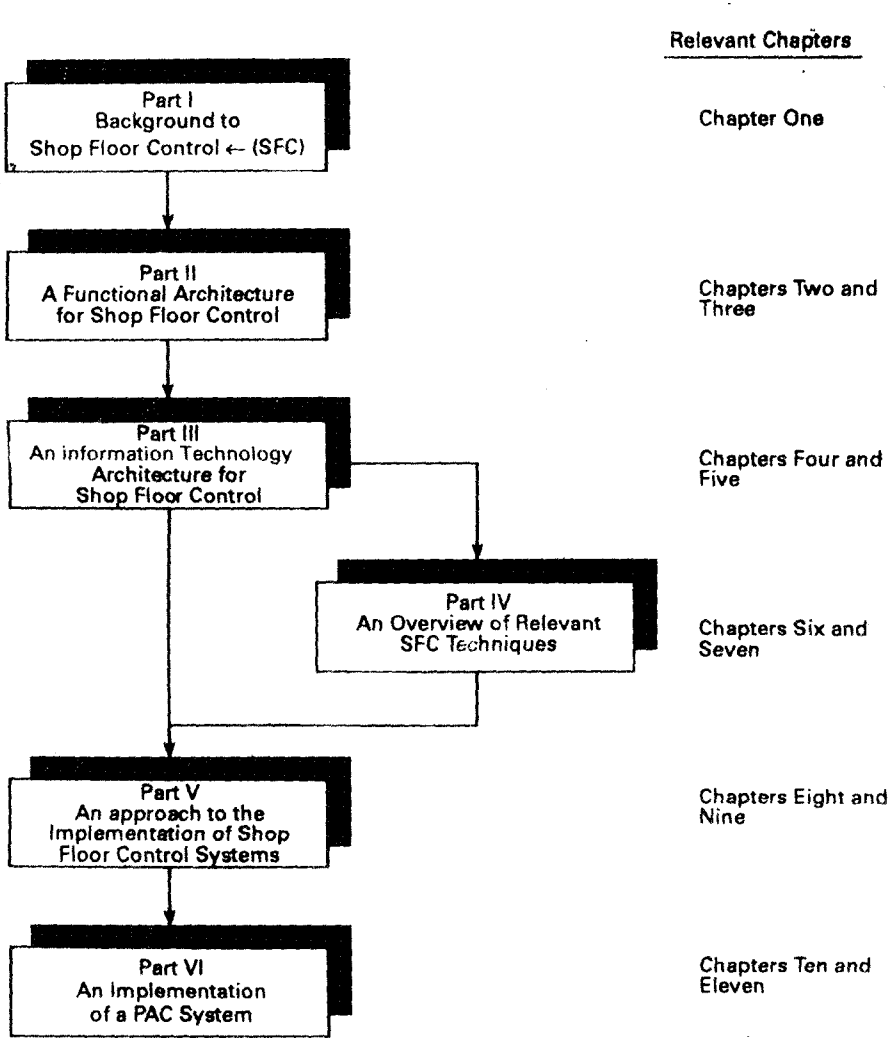
Customers are demanding high quality products and very fast turn around on orders. Manufacturing personnel are aware of the lead time from receipt of order to delivery of completed orders at the customer's premises. It is clear that this production lead time is, for the majority of manufacturing firms, greatly in excess of the actual processing or manufacturing time. There are many reasons for this, among them poor coordination between the sales and manufacturing function. Some are within the control of the manufacturing function. Others are not.

This book is concerned with manufacturing lead time, i.e the time from when a batch enters the shop floor to the time it leaves manufacturing as a finished part or product. Typically this manufacturing lead time is 10 to 20 times the actual processing time. It is our contention that this manufacturing lead time must be reduced to a level comparable to the actual processing time. Further this can be achieved by the use of sound operational planning and control systems. Hence the focus of our book is on operational level production planning and control systems; normally referred to as shop floor control systems. Our experience suggests that conventional commercially available computer based systems are very weak on this aspect of production planning and control.

In this book we present an overall approach to the development and installation of sophisticated shop floor control (SFC) systems. This is achieved by offering a functional architecture for SFC, outlining a corresponding information technology architecture, offering some ideas on how SFC systems should be installed – essentially adapting a sociotechnical approach to design and installation – and developing a set of software tools to support the development and installation of SFC systems. The overall approach is verified by an industrial case study which concludes the book.

Our book is concerned primarily with the control issues within SFC and how these can be resolved using state-of-the-art software tools. We address implementation issues in terms of the approach, which we believe should be adapted to implementation. We do not, for instance, discuss implementation in terms of the devices which might be used to capture data from the shop floor.

The structure of the book is as shown in the following figure. Initially we present a short overview of the various approaches to production planning and control, position SFC below the requirements planning stage and suggest that it involves two major activities, factory coordination and production activity control (Part One). We present functional architectures for each of these sub-systems and outline in detail the building blocks within each subsystem. The functional architecture is also documented using the SADT™ (Structural Analysis and Design) approach (Part Two). In Part Three we outline an information technology architecture which matches the functional architecture presented in Part Two. Part Four presents a short summary of the state of the art in the various techniques associated with factory coordination and production activity control. (This part breaks the flow of the book but we believe it is important to offer the reader an overview of the state of the art in important relevant topics such as group technology, scheduling etc.) We discuss the design and implementation of these systems in Part Five and in particular present some ideas for an application generator for the design and development of PAC systems. We are very conscious of the difficulty of implementing such systems in practice, and thus we emphasize the importance of an implementation approach which involves likely end users from the beginning. Finally in Part Six we present a case study of the use of the software tools and the implementation of our ideas in an industrial plant.



The structure of the book

FOREWORD

The modern environment of discrete parts manufacturing is sophisticated and intensely competitive. It is characterized by short product life cycles, high product diversity, and customers' demands for both excellent quality and timely delivery. If the production operation is capable of responding to these challenges, manufacturing can be a source of real competitive advantage for the business. Otherwise, the manufacturing process could become an inflexible and expensive corporate liability, and business strategists might do well to consider external sourcing of company products.

For manufacturing managers, then, the challenge is to develop a finely tuned process, capable of meeting the cost, quality, variability and time pressures imposed by the marketplace. Our primary objectives must include the reduction of manufacturing lead time to the minimum possible, and achievement of a high level of process control. The benefits accruing from such efforts should include: greater flexibility and responsiveness, better use of manufacturing resources, reduced inventory levels, and faster turn around on customer orders.

Fortunately, advanced information technology now brings the realization of such objectives within reach. It makes explicit and feasible the desire to reduce manufacturing lead time to a level approaching the actual time spent in material conversion on the shop floor. However, the application of sophisticated technology alone is unlikely to yield a durable and efficient shop floor strategy.

There is a need for a well-defined and consistent architecture which describes the production management environment within which shop floor activities take place. On the shop floor, there is a need to link and re-focus all of the discrete stages which make-up the process, so that the total manufacturing operation can be optimized. Furthermore, there is a need to understand the organizational implications of new shop floor control (SFC) technologies. Only by integrating the capabilities of manufacturing personnel, process

technologies and advanced information technology can manufacturing continue to contribute to business competitiveness.

This book provides a balanced and pragmatic view of the capabilities of advanced SFC principles and their implementation in real manufacturing environments. It draws together a wealth of information technology knowledge, manufacturing experience and an appreciation of the organizational impacts of SFC designs and technologies, within a sociotechnical framework. It thus makes an invaluable contribution to the education of manufacturing professionals, who find it difficult to keep abreast of such a diverse, and yet critical, amalgam of disciplines.

As a manufacturing manager I am delighted to be associated with this book. While my contribution is limited to this Foreword, I am happy to have been involved in the development of the manufacturing operations at Digital's Clonmel facility, described in the text. Much of this book is based upon research work completed under the auspices of the European Commission sponsored ESPRIT programme. This programme not only assembled the critical mass of five authors which gave birth to this book, but also brought them into close collaboration with colleagues from other European manufacturing industries, most notably COMAU S.p.a. (of Turin, Italy) and RENAULT Automobiles (of Paris, France). I believe the breadth of experience, manufacturing strategies, technologies and corporate cultures observed in all of these industries has been distilled in this text.

Denis McPhail
Plant Manager, Clonmel Manufacturing Facility
Digital Equipment International B.V.
Clonmel, Ireland.

CONTENTS

FIGURES