Optimal Policies for Spares in Multi-Echelon Repair-Inventory Systems

by

Arjunan Subash Babu
Department of Mechanical Engineering

Submitted in fulfilment of the
requirements for the degree of
Doctor of Philosophy

to the

Indian Institute of Technology, Delhi

October 1980

DEDICATED TO

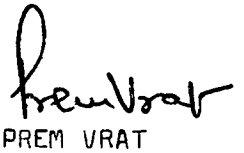
MY PARENTS

MY TEACHERS

MY UNCLE MR. V.A. RAMANUJAM

CERTIFICATE

The thesis entitled 'Optimal Policies for Spares in Multi-Echelon Repair-Inventory Systems' being submitted by Mr. Arjunan Subash Babu to the Indian Institute of Technology, New Delhi, for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision, and has fulfilled the requirements for the submission of this thesis, which has attained the standard required for a Ph.D. degree of the Institute. The results presented in this thesis have not been submitted elsewhere for the award of any degree or diploma.



PREM VRAT

Professor of Industrial Engineering
Department of Mechanical Engineering
Indian Institute of Technology
New Delhi

ACKNOWLEDGMENTS

The author is very much indebted to Dr. Prem Vrat, Professor of Industrial Engineering, Department of Mechanical Engineering, Indian Institute of Technology, New Delhi, for the initiative, guidance and encouragement received during the course of this research.

The author thanks the Indian Institute of Technology, New Delhi, for providing the necessary facilities, and Delhi Transport Corporation for extending their help while collecting the data.

The various helps and encouragements extended by Dr. M.K.G. Babu, Mr. K. Kumar, Mr. K.S. Reddy and Mr. B.P. Reddy are gratefully acknowledged and the author feels indebted to them for their kind interest and understanding. The author also takes this opportunity to thank Jayanthi, Shiv, Kumbhar, Banwet and others for their interest.

Thanks are also due to Mr. P.M. Padmanabhan Nambiar, for his excellent typing and Mr. Kapoor for his neat drawings.

A. SUBASH BABU

ABSTRACT

Investigations reported in this thesis consider the problem of optimal provisioning of expensive and slow moving spares in multi-echelon repair-inventory systems pertaining to important public utility sectors, like road transport corporations, with the general theme of achieving total effectiveness by developing integrated logistics systems for such organisations. The thesis consists of ten chapters, divided into six sections.

The first section consists of two chapters. In the first - introductory chapter, the functional importance and types of inventory systems; the relevance, structure, characteristics and parameters of the general multi-echelon and multi-echelon repair-inventory systems are discussed. In the second chapter, the general multi-echelon inventory systems are classified and reviewed in a consolidated manner with pictorial and tabular schemes, whereas, the available literature on multi-echelon repair-inventory systems is reviewed extensively.

In the second section consisting of one chapter, a'total system cost'model is developed for a two-level repair-inventory system, using which, optimal inventory policies are evaluated to minimise the total system cost for a metropolitan bus transport corporation. The individual and joint impacts of optimal location and maintenance effectiveness of the central facility on the system performance and spare stock are investigated.

The next section consists of four chapters. Here, a computer simulation model is developed for the two-level system. The validity, adequacy, applicability, adaptability and predictability of the model are statistically verified, and the evaluation of optimal policies for the Transport Corporation is carried out. With the help of suitable simulation models, the effects of incorporating cannibalization and transhipment individually and jointly, on the system performance and spare stock are investigated. The observations are statistically analysed using the Analysis of Variance and Spectral Analysis.

The fourth section with one chapter, presents an alternative system in three-level configuration with a total cost model. Optimal inventory policies are evaluated for the proposed system. The effects of configuration and number of echelons on the performance and spare stock of multi-echelon repair-inventory systems are investigated.

In the fifth section consisting of one chapter, the effect of budget constraints on system performance, namely, system availability and total system cost are investigated. Using suitable approximations, mathematical models and solution methodologies are developed to determine optimal inventory policies (spares provisioning/rationing) for various budgetary levels, in order to maximise the system availability and minimise the total system cost.

In the last section, that is in the concluding chapter, the summary of the research/findings is given; the contributions/developments of the research are highlighted; the limitations/shortcomings

are listed and the possible extensions/problems for future research are suggested.

An extensive bibliography is included on the subject. The Appendices of the thesis contain detailed flow charts, computer listing etc. which support the main text.

A substantial part of the research reported in this thesis has been published by the author in various International Journals and Conferences. A list of publications based on the work reported has been given at the end.

CONTENTS