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**Dissertation Abstracts with  
the Theory of Constraints  
at the University of Georgia**

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## **Dissertation Abstracts with the Theory of Constraints at the University of Georgia**

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1999

Lynn Howard Boyd

**Production Planning and Control and Cost Accounting Systems:**

**Effect on Management Decision Making and Firm Performance**

**(Under the direction of James F. Cox III)**

Cost accounting systems and production planning and control have evolved significantly over the past 75 years. While both direct costing and labor-based allocation of overhead costs have been used for much of the 20<sup>th</sup> century, activity-based costing and the theory of constraints, while includes elements of a cost system, have been developed only in the last 15 to 20 years. In production, reorder point systems were most common for most of this century, but development of JIT in Japan starting in the early 1950s and MRT in the U.S. starting in the late 1960s have brought significant changes. In addition, the theory of constraints also includes production management techniques. While the cost accounting and operations management literatures each include comparisons of the four systems in their respective areas, neither literature includes comparisons of the four systems in their respective areas, neither literature includes comprehensive comparisons of *combinations* of production planning and control systems and cost accounting systems. The comparisons that have been done have been limited to simple examples developed to illustrate the superiority of one or another of the systems under certain conditions, and generally compare either cost accounting systems or production planning and control systems while holding the other system fixed.

A systematic comparison of combinations of the four cost accounting systems and four production planning and control systems under a wide range of circumstances that allows identification of the conditions under which any combination of the systems might result in superior management decisions and improved firm performance was undertaken. The results suggest that the theory of constraints provides both superior decisions and superior operating performance.

**INDEX WORDS:** Activity-based costing, Cost accounting, Direct costing, Management decision making, Material requirements planning, MRP, Production planning and control, Reorder point, Theory of constraints, TOC

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1998

Edward Davis Walker, II

**Planning and Controlling Multiple, Simultaneous,  
Independent Projects in a Resource Constrained Environment**

**(Under the direction of James F. Cox, III)**

The purpose of this dissertation was to develop a more effective planning and control technique for the management of multiple, simultaneous, independent projects in a constrained resource environment. A significant amount of research has been conducted on projects planned and controlled in the single project environment; however, far less research has explored the planning and control of projects in the multiple project environment. First, problems with current PERT-based methods of planning and controlling single projects was re-examined through the use of simple thought experiments (*gedankens*). Second, the problem with PERT-based methods of planning and controlling multiple projects were identified logically (via a current reality tree) and isolated, analyzed, and verified using *gedankens*. Third, a heuristic was developed to plan and control projects in a multiple project environment.

After the problems had been identified and a new heuristic had been developed, the execution of the proposed heuristic and traditional methods were simulated on a large set of large projects (31 projects of 60-80 activities each). The results of the simulation showed that the proposed heuristic performed better than traditional methods on four summary measures of project success - mean percent of early completions, mean lateness as a percent of planned project duration, mean earliness as a percent of planned project duration, and mean resource utilization.

**INDEX WORDS:** Project management, Resource constrained scheduling, Buffer management, Theory of Constraints, Critical chain

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1995

Seonmin Kim

**An Investigation of Flow Control Mechanisms in  
Semiconductor Wafer Fabrication**

**(Under the direction of Dr. K. Roscoe Davis)**

Semiconductor wafer fabrication (FAB) is a highly complex, capital-intensive process with rapidly changing manufacturing technologies. Because of the complexity of the semiconductor wafer fabrication process (which includes multiple products, resource contention, revisiting characteristics, etc.), it is difficult to introduce material into the line at the appropriate place in the line. In this environment, it is imperative to manage and control the flow of material in order to maintain the desired output rate with minimal inventories. Real-time based flow control mechanisms such as Dynamic Flow Control (DFC) and Starvation Avoidance (SA) have been developed to manage the flow of material; however, because of their dependence on up-to-date real-time information, it would be preferable to have a simplified flow control (non-real time data dependent) mechanism for managing/controlling the flow of lots in a FAB. This dissertation attempts to answer the question, "Can simplified flow control mechanisms be applied in a FAB?"

This dissertation tests two simplified flow control mechanisms as effective techniques for scheduling in a FAB. Output Flow Control (OFC), the concepts captured in the CONWIP system, manages the flow of material by tying the output rate back to the input rate. Bottleneck Flow Control (BFC), the concepts captured in Drum-Buffer-Rope (DBR), manages material flow by tying the bottleneck output rate back to the input rate.

This study explores OFC and BFC in conjunction with dispatching rules to determine if the production system performance of a semiconductor wafer fabrication using DFC can be achieved with these simple techniques. Small manufacturing line models are initially used to compare OFC and BFC with DFC, while a large-scale FAB model is used to compare them with DFC. Simulation analyses give insight into the performance of OFC and BFC.

The results of simulation analyses show that BFC/FIFO is a flow control mechanism comparable to DFC, in that it produces near product mix performance of DFC/DFC in the case of breakdowns and variations in processing times in a FAB, while reducing WIP inventories considerably. In addition, in the analysis of simple manufacturing lines, BFC/FIFO provides good performance in the majority of scenarios considered.

**INDEX WORDS:** Production Inventory Management, Flow Control Mechanism, Material Release Strategy, Dispatching Rule, Output Flow Control, Bottleneck Flow Control, Dynamic Flow Control, Simulation, Semiconductor Wafer Fabrication

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1994

**Rexford Henry Draman**

**A New Approach to the Development of Business Plans:**

**A Cross-functional Model Using the Theory of Constraints Philosophies.**

**(under the direction of James F. Cox, III)**

Over the last 50 years the purpose and complexity of business planning has changed. Initially, business plans resulted in the development of annual operating budgets. Over time, business plans expanded to include the development of long-term (2-5 years) budgets. Then, as global competition grew more intense, business plans evolved into a more complex process called strategic planning. Strategic planning has evolved into what is referred to today as strategic management (Judson, 1990). During the last 50 plus years the approaches and techniques used to develop business plans have continually evolved to meet the needs of an ever changing environment. The traditional process for developing a business plan evolved over the years to meet new challenges ... [as such] ... they are a patchwork of subsystems and additions” (Camillus, p. 4) based upon the beliefs and logic of the past.

In an effort to improve the business planning process this research used a non-traditional perspective as the basis for its investigation. Instead of using the traditional logic, beliefs, and measures (those based on cost accounting) for developing a business plan, this research uses the logic, beliefs, and measures contained within the Theory of Constraints (TOC) philosophy.

Before a TOC-based approach for developing a business plan could be developed, the problems with the current approach had to be identified and analyzed. The first research question was to document the differences in organizational performance between using traditional and TOC logic and measures. The decisions based upon the traditional approach (cost accounting logic and measures) produced poorer organizational performance than the decisions based upon the TOC approach.

These results provided the necessary support for progressing to the next research question. The second research question focused on conceptualizing a new approach to business planning based on the logic and philosophy of TOC.

Prior to implementing the new business planning approach in a business preliminary testing was undertaken to establish its potential value. This testing was in response to the third research question. “Does the TOC business plan in theory, produce better organizational performance than the traditional approach (cost-based measures) for various strategies?” Two experiments (gedanken and simulation) were developed to evaluate the impact of the TOC-based planning process on organizational performance. In both experiments the different approaches (TOC and traditional) were matched based upon five alternative business strategies. The TOC approach outperformed the traditional approach in both experiments.

These results led to the fourth research question of testing the process for usability in a business. This effort involved identifying a participant organization and conducting an intervention to develop a TOC based business plan using the TOC approach to business planning.

Finally, an evaluation of the business plan and the development process was conducted to determine the usability of the TOC-based business planning process. The members of the management team involved in the intervention praised the final TOC business plan as an excellent road map to their chosen organizational objective. Their primary concerns focused on the intervention process itself.

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1994

Christian M. Lutz

**Determination of Buffer Size and Location  
in Scheduling Systems**

**(Under the direction of K. Roscoe Davis)**

Competition among companies is becoming more and more fierce. In addition to increased quality conformance, companies with short manufacturing (cycle) times can gain competitive advantages. Short cycle times are achieved by having viable scheduling systems that require minimal inventories. Many scheduling systems such as Kanban, Drum-Buffer-Rope (DBR), and CONWIP, as well as a new system referred to as Dynamic Flow Control (DFC), have been developed that seek to achieve these competitive advantages (objectives). But, most of these systems fall short of achieving these objectives because they do not clearly identify where and how much inventory should be employed.

Obviously, zero inventory is inefficient and some inventory is needed in a manufacturing line. However, the exact determination of total inventory quantities and the determination of the location and size of work-in-process (WIP) inventories is difficult. It is difficult, since it is impossible to forecast the impact of all statistical fluctuations, which is needed to determine work-in-process inventory structures. Many real-world manufacturing lines side-step the problem by employing high finished inventory levels. However, there is a tradeoff in setting inventory levels and inventories should not necessarily be set at high levels. On the other hand, too low inventory levels starve work centers which reduces line performance. On the other hand high WIP inventory levels result in long manufacturing cycle time, which operates counterproductive to the competitive advantage of a firm.

This dissertation deals with problems of WIP inventory management and provides a simulation-search procedure which can be used to determine inventory size and location requirements of a firm. It shows that the size and location of WIP inventory is a combinatorial problem which is a function of buffer sizes at each operation in a manufacturing line. This study identifies specific inventory locations and minimal sizes, referred to as "inventory profiles," which support manufacturing scheduling systems. Because of the complexity of the profiling process, simulation, combined with an artificial intelligence based search heuristic, is employed to address the problem. Simulation is used to model the manufacturing facility under study, while a Tabu Search metaheuristic is used to analyze the simulated results, to direct the search process in the combinatorial environment, and to identify optimal or near optimal buffer profiles.

**INDEX WORDS:** Manufacturing Line, Order Push System, Demand Pull System, Inventory Capacity Profiles, Inventory Target Profiles, Simulation, Artificial Intelligence, Tabu Search

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1994

James William Putt

**A Comparison of Production Control Methods**

**for a Serial Flow Shop with Setups**

**(Under the direction of John H. Blackstone, Jr.)**

Kanban is used by many who implement Just-In-Time (JIT) concepts and is noted for low inventory and short lead times. It has been used successfully where the internal and external environments are stable. This limits the applicability of Kanban to a narrow range of manufacturing environments where variability can be reduced. The sensitivity of Kanban to such factors as setup time, lot size, and work center failure rate has caused some manufacturers to abandon Kanban and sometimes JIT.

Kanban is not the only production and inventory control method that can function with low inventory and short lead times. The purpose of this research is to compare the production and inventory control methods of Drum-buffer-rope (DBR) and Kanban.

Drum-buffer-rope, a method developed as part of the "Theory of Constraints", is compared directly with Kanban in a serial flow shop environment. Independent variables used in this study are setup time, process batch size, transfer batch size, work center failure rate, protective inventory, protective capacity and number of work centers. Dependent variables are total units produced, average inventory, and lead time. All simulations use computer programs written in Fortran. Results are analyzed using analysis of variance (ANOVA) for main and two-factor effects. Tukey pairwise comparisons are also used to analyze main factor effects.

Results show that DBR, relative to Kanban, has higher output, shorter lead time, and lower average inventory. DBR should be given consideration as the production and inventory control method of JIT implementations.

**INDEX WORDS:** Kanban, Just-in-Time, JIT, Drum-Buffer-Rope, Theory of Constraints, TOC, Production and Inventory Control, Simulation

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1993

Paul Howard Pittman

**Project Management: A More Effective Methodology for the  
Planning and Control of Projects**

**(Under the direction of James F. Cox, III)**

The purpose of this dissertation was to develop a more effective planning and control technique for project management environments. Though a significant amount of research has been conducted in the area of project management, analysis of the literature indicates that very little of it has taken a systems perspective in addressing the problems associated with planning and controlling projects. First, the problems with current (traditional) project planning and control techniques were identified, isolated, verified, and analyzed by using simple exercises and experiments. Second, larger project networks were constructed to simulate the impact of the previously mentioned problems on project completion times.

After the problems with current project management techniques have been analyzed, an improved approach for the planning and control of projects, including control guidelines to follow during project execution was developed. Finally, the simulation results of projects executed using current techniques were compared to the same projects executed using the improved approach to determine which technique was more effective in predicting actual project completion time. Only single projects with both single and multiple resources were examined, however, many of the concepts developed have direct applications to multi-project environments.

**INDEX WORDS:** Project Management, Buffer Management, Theory of Constraints, Resource Constrained Scheduling, Critical Chain

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1993

James Ludwig Wahlers

**A Study of Performance Measure in an  
Intermittent Synchronous Manufacturing Environment  
(under the direction of James F. Cox, III)**

Performance measurement in manufacturing organizations has become an issue of major concern for both academics and practitioners in the past several years. For example, the 1988 American Production and Inventory Control Society (APICS) Conference Proceedings had, for the first time, a section containing fourteen articles, devoted exclusively to performance measurement and performance measurement systems. In contrast to this, the 1987 APICS Conference Proceedings contained only five articles that were concerned with performance measurement.

Thomas Vollmann (1988, p. 3) writes:

... Manufacturing performance should be contingent upon manufacturing goals. As certain goals are achieved, new ones should be developed. As the marketplace changes, new responses are required. All of this means that performance measures can and should be changed. The companies that position themselves to make these changes faster, with less conflict, will be winners.

Much of the writing focusing on performance measurement has been concerned with traditional performance measures. The need for improving existing measures of productivity, departmental efficiency, machine utilization, product costs, material costs, cost variations, overhead allocation are common topics.

Management accountants have recognized the inadequacies of existing measures. Deficiencies in accounting systems as they related to performance measures were identified by Robert Kaplan in his 1983 article, "Measuring Manufacturing Performance: A New Challenge for Managerial Accounting Research" published in the *Accounting Review*. Current literature comments on the inadequacies of existing performance measurement systems. Few of the researchers, either in the accounting or operations management literature, give examples of new or modified measures of manufacturing performance that are used by practitioners.

This dissertation studies new or modified performance measures used by five intermittent manufacturing organizations. The firms selected to participate in this research have indicated that they have recently changed their performance measurement system. These companies use various production/inventory control systems to schedule their operations and to control their inventories, e.g., Material Requirements Planning (MRP), Manufacturing Resources Planning (MRP II), the philosophy of waste elimination advocated by Just-in-Time (JIT), or the scheduling rules and Theory of Constraints philosophy developed by Elyiahu Goldratt. Some of the companies studied use two or more of these techniques in combination.

The purpose of this dissertation is to develop from a study of the performance measurement sys-

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tems used by the participating firms a series of propositions. These propositions will serve as guidelines for practitioners interested in the development of effective performance measurement systems. Additionally, the propositions will serve as a basis for future research as more firms adopt new performance measurement systems.

Specifically the following research questions are addressed:

1. What are the performance measures used by synchronous intermittent manufacturing organizations?
  2. Are consistent performance measurement systems used to evaluate performance throughout the manufacturing operations of these firms?
  3. Does the performance measurement system support the competitive factors emphasized by the organization?
  4. How are manufacturing performance measures used by the organization?
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1992

Satya S. Chakravorty

**A Simulation Study of the Performance of a Multi-Echelon  
Production-Distribution System With Feedback and  
Feed forward Controls**

**(Under the direction of Dr. John H. Blackstone, Jr.)**

The purpose of this research is to study the performance of a multi-echelon production-distribution system with feedback and feedforward controls. To conduct the research two simulation models were developed. The simulation model with feedforward controls is a distribution requirements planning (DRP) system. A DRP system works backwards from the forecast of demand at the retailer(s) to compute the time-phased requirements of orders at all levels of a distribution system. The simulation model with feedback control is a pull/replacement (P/R) system. A P/R system replenishes the items which have been consumed in the preceding period.

This research had two primary objectives. The first objective was to identify the factors which affect the performance of a DRP system (feedforward control). The second was to identify the conditions, if any, under which the P/R system (feedback control) performs better than the DRP system.

Nine factors - demand pattern, demand variability, shift in demand, forecast responsiveness, ordering frequency, safety stock, plant capacity and distribution structure were considered to determine which ones affect the inventory turns (throughput/inventory) of the DRP system. The study concluded that all but safety stock affected the inventory turns of a DRP system.

To determine the conditions under which the P/R system performs better than the DRP system 7 conditions were identified. They were: demand pattern, demand variability, shift in demand, ordering frequency, safety stock, plant capacity and distribution structure. The study found that under all combinations of 7 conditions the P/R system produced significantly higher inventory turns the DRP system. The study concluded that the P/R system is a simpler, more effective and cheaper solution to plan and control a distribution system compared to the ineffective and expensive DRP system.

**INDEX WORDS:** Feedback, Feedforward, Distribution Planning, Distribution Requirements Planning, Drum-Buffer-Rope, Multi-Echelon Production-Distribution System, Pull Replacement

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1992

**Vincent Daniel Richard Guide, Jr.**

**A Simulation of Present Production Planning and Control Versus**

**Synchronous Manufacturing at a Naval Aviation Depot**

**(Under the direction of Dr. John H. Blackstone, Jr.)**

The purposes of this study were to determine if the principles of synchronous manufacturing produced superior performance in comparison with current production planning and control at a Naval Aviation depot and how to determine buffer sizes for use with drum-buffer-rope in a repair/remanufacture environment. This investigation used two simulation models of an actual repair/remanufacture facility to compare performance with respect to completion to schedule, repair lead time, time-in-system, work-in-process levels, part idle time and the number of units exceeding the allowed time-in-system.

A method of determining the required buffer sizes to be used in conjunction with drumbuffer-rope is developed and discussed in detail. The results of the simulation models are discussed fully and the implications of these results are discussed fully.

**INDEX WORDS:** Remanufacture Industry, Synchronous Manufacturing, Theory of Constraints, Drum-Buffer-Rope, Repairable Inventory Systems, Production Planning and Control

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1992

Marsha J. Kwolek

**An Analysis of Performance Measurement Systems in  
the Air Force Logistics Command's Aircraft Repair Depots**

**(Under the direction of James F. Cox, III)**

This dissertation explores the goals and objectives, competitive edges, performance criteria, and system constraints of a selected group of depot maintenance organizations in the Air Force Logistics Command's (AFLC's) aircraft repair depots. Through interviews of managers at the directorate, division, branch, and first-line supervision levels, the selected organizations were asked to identify the competitive edges on which they compete. The organizations were then studied at the directorate, division, and branch levels to determine how performance on the critical competitive edges is measured and to identify the constraints that prevent the depots from achieving their objectives. The results of this research were: (1) The development of guidelines concerning AFLC goals and depot objectives, competitive edges, performance criteria, and system constraints; and (2) A prescriptive depot maintenance performance model showing the desired relationships among proposed depot objectives, critical competitive edges identified by AFLC managers (quality, cost, and delivery), proposed performance criteria, and current system constraints. Due to the exploratory nature of this research, a case study methodology was employed.

**INDEX WORDS:** Aircraft Maintenance, Competitive Edges, Depot Maintenance, Performance Measurement Systems, System Constraints, Theory of Constraints

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1992

Michael Shea Spencer

**Production Planning and Control Systems in Repetitive Manufacturing:**

**A Comparative Analysis Based on the Product-Process Structure**

**(Under the direction of James F. Cox, III)**

This dissertation explores three production planning and control systems: (1) Material Requirements Planning; (2) Just-In-Time Manufacturing; and (3) The Theory of Constraints operating in a repetitive manufacturing environment. The analysis is based on a comparison among the three systems based on the product-process structure. The research methodology was based on case studies of nine cells of a matrix consisting of the three production planning and control systems versus the three logical structures V, A, and T. The end results of the research effort were an improved operating definition of repetitive manufacturing, the identification of key characteristics of the three production planning and control systems operating in the three logical structures, and a prescriptive model of production planning and control systems operating in a repetitive manufacturing environment.

**INDEX WORDS:** Manufacturing Planning and Control, Material Requirements Planning, Just-in-Time, Theory of Constraints, Repetitive Manufacturing, Production Planning and Control

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1991

Joseph Brian Atwater

**The Impact of Protective Capacity on the Output of a Typical Unblocked Flow Shop**

(Under the direction of John H. Blackstone, Jr.)

The purpose of this dissertation is to study the impact of protective capacity on the output of a typical flow shop. For this study protective capacity is defined as:

***Protective Capacity:** the difference between the output rate of a non-constraint resource and the constraint resource which is **required** to achieve a given level of output at the constraint.*

The study is an extension of research on the unbalancing of single model stochastic production lines. Most notably the 'bowl phenomena' proposed by Hillier and Boling (1966).

To conduct this study a simulation model of a nine station flow shop using the drum-buffer-rope logistic system was developed. System output was used as the dependent variable and levels of WIP inventory, average level of protective capacity, station coefficient of variation, average station repair time, and average station down time were used as independent variables. Partial correlation coefficients were used to identify the type and strength of the relationship between average protective capacity and the other independent variables. Multiple regression models were constructed, which were used to develop a set of isoquants. The isoquants show the various combinations of protective capacity and WIP inventory required by the system to achieve a desired output, for given combinations of the other independent variables.

This study shows clearly that average protective capacity has an impact on the output of a line. By adding protective capacity to a line with a fixed level of WIP the output rate of that line will increase; conversely, for a specified level of output adding protective capacity allows for a reduction in the necessary level of WIP inventory. The study also showed that arrangement of protective capacity can play a role in increasing the output level of a line for certain combinations of WIP inventory and average protective capacity.

**INDEX WORDS:** Flow Shop, Protective Capacity, Capacity Planning, Drum-Buffer-Rope, Unbalanced Production Lines, Single Model Stochastic Production Lines

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1991

Archie Lockamy, III

**A Study of Operational and Strategic Performance Measurement**

**Systems in Selected World Class Manufacturing Firms:**

**An Examination of Linkages for Competitive Advantage**

**(Under the direction of James F. Cox, III)**

This dissertation explores the performance measurement systems of a selected group of manufacturing organizations identified as world class by academic and practitioner experts. Corporate culture, inter- and intra-organizational interactions, and periodic performance reporting were found to be instrumental in providing the firms with performance measurement system linkages between organizational levels and across functional areas. The end results of this research effort were: (1) The development of analytical generalizations concerning strategic objectives, performance measurement systems and performance measurement system linkages; and (2) A set of theoretical performance measurement system models showing linkages between the plant and division levels of the firm for cost, quality, lead time and delivery objectives. Due to the exploratory nature of this research project, a case study methodology was used.

**INDEX WORDS:** Manufacturing Strategy, Performance Measurement Systems, Performance Measurement Systems Linkages, Strategic Objectives, World Class Manufacturing

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