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by

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Declaration

I hereby declare that this thesis has been composed by myself and has not been presented or accepted in any previous application for a degree. The work, of which this is a record, has been carried out by myself unless otherwise stated and where the work is mine, it reflects personal views and values. All quotations have been distinguished by quotation marks and all sources of information have been acknowledged by means of references including those of the Internet.

Yevvon Yi-Chi Chang

January 2006
Abstract

Mass customisation (MC) is a manufacturing strategy that enables high volume production at low unit cost, while providing customised or personalised products or services. Flight caterers face the pressure of providing high volumes of meals each day, and the need to provide different menus for several different airlines at the same time. The concept of MC allows the high volume and high variety issues to be achieved with no trade-offs. To date, there are no existing published articles pertaining to MC in the flight catering business. Therefore, this study will be the first attempt to investigate the operational processes of the flight catering industry in relation to MC, and determines the MC mode for this industry. However, MC is a general concept which may include a number of dimensions such as labour flexibility, just-in-time (JIT), modularity, lean production, and flexible/agile manufacturing strategies. Various factors are investigated in order to try to understand their relative contributions to improved efficiency.

This study was carried out by means of a combination of qualitative and quantitative approaches. In the exploratory study (Stage One), secondary data, on-site observations and interviews were adopted to conceptualise the nature of operations processes in flight catering. In particular, the specific MC mode adopted by this industry is found to be categorised as ‘Mode E: flexible resource call-off MC’, by comparing elements in relation to the five fundamental MC modes proposed by MacCarthy et al. (2003). For the main study, a quantitative approach was adopted using Data Envelopment Analysis (DEA) to identify efficient and inefficient flight catering units in Phase I. Subsequently in Phase II, qualitative case studies on the efficient and inefficient units were developed to identify and understand important factors (inputs and outputs) in the operational process that have significant contribution to the performance of the flight catering industry.

The findings from the main study have identified traits of MC in current flight catering operations. In particular, the finding has identified labour flexibility, the efficiency of alternative set-ups for tray assembly, the potential of JIT principles, the application of forecasting and material requirement planning, and the existence of modularity in a variety of forms, in flight catering operational practices. However, there was limited evidence that MC had been fully adopted. The most significant finding is that the flight catering industry does not operate on economies of scale. This was highly unexpected, as the most manufacturing plants in other industries operate based on the principle of economies of scale.
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<tr>
<td>AB</td>
<td>Air Berlin</td>
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<td>BA</td>
<td>British Airways</td>
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<tr>
<td>B/C</td>
<td>Business Class</td>
</tr>
<tr>
<td>BBC</td>
<td>Banker, Charnes and Cooper</td>
</tr>
<tr>
<td>CCR</td>
<td>Charnes, Cooper and Rhodes</td>
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<tr>
<td>CIM</td>
<td>Catering Instruction Manual</td>
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<tr>
<td>CQ</td>
<td>Continental Airlines</td>
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<tr>
<td>CX</td>
<td>Cathay Pacific Airways</td>
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<tr>
<td>DEA</td>
<td>Data Envelopment Analysis</td>
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<tr>
<td>CMU</td>
<td>Configurable Manufacturing Unit</td>
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<td>DMU</td>
<td>Decision Making Unit</td>
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<tr>
<td>CNC</td>
<td>Computer Numerical Control</td>
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<td>E/C</td>
<td>Economy Class</td>
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<tr>
<td>EK</td>
<td>Emirates Airlines</td>
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<td>EAE</td>
<td>European Air Express</td>
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<tr>
<td>F/C</td>
<td>First Class</td>
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<tr>
<td>FCMS</td>
<td>Flight Catering Management System</td>
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<tr>
<td>FMS</td>
<td>Flexibility Manufacturing System</td>
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<tr>
<td>Ford</td>
<td>Ford Motor Company</td>
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<tr>
<td>HACCP</td>
<td>Hazard Analysis and Critical Control point</td>
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<td>KE</td>
<td>Korean Air</td>
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<td>KPI</td>
<td>Key Performance Indicator</td>
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<td>ITCA</td>
<td>International Travel Catering Association</td>
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<td>JAL</td>
<td>Japan Airlines</td>
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<td>JIT</td>
<td>Just-In-Time</td>
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<td>LTU</td>
<td>International Airways</td>
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<td>LP</td>
<td>Lean Production</td>
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<td>MHS</td>
<td>Material Handling System</td>
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<td>MRI</td>
<td>Minimum Reasonable Inventory</td>
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<td>MC</td>
<td>Mass Customisation</td>
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<td>MRP</td>
<td>Material Requirements Planning</td>
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<td>Push System Running</td>
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<td>TQM</td>
<td>Total Quality Management</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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Chapter 1 Introduction

1.1 Background

Over the years, consumers' ever changing needs have become more demanding and traditional manufacturing strategies can no longer cope. Since the inception of mass customisation, a number of alternative views on this new manufacturing strategy have been expressed. It has been touted as the next great manufacturing paradigm to succeed mass production (Toffler, 1970; Davis, 1987; Pine, 1993). On the other hand, mass customisation is described as only one of several current manufacturing initiatives (Sahin, 2000), and a lowly 'buzz phrase concept' with both limited novelty and restricted applicability (Spring and Dalrymple, 2000). Notwithstanding how the concept of mass customisation is viewed, a number of mass customisation successes have been identified, both in industry and in the research literature (Da Silveira et al., 2001). Most prominent are the high profile companies in service as well as consumer product sectors such as McDonalds (Taylor and Lyon, 1995), Hewlett-Packard (Feitzinger and Lee, 1997) and Dell (Magreta, 1998). From the achievements of successes like these, mass customisation has gradually become more than just a popular means for manufacturers to attain a competitive advantage. It may prove to be the key element for the future survival of a number of manufacturers in diverse industries (Anderson and Pine, 1997).

Traditionally, manufacturing processes are being classified into five types: project, job shop, batch, mass and continuous processing. The choice of processes then depends on the company's desired levels of product volume, product range and speed of production that would meet the demands of the market. In the flight catering business, volume of products that include, beverages, snacks, confectionary, breads, appetizers, meats,
vegetables, desserts, salads, cheeses, soft drinks, beers and wines are provided on a daily basis. On top of that, flight caterers have to concern themselves with a variety of outputs, for instance, the different airlines that needed to be served, menus for different classes (economy, first and business classes) and the variety of special meals. The magnitude of this variety issue is further compounded by the need to manufacture a wide range of products in a relatively short time. However, it has been shown that there are compromises in achieving high volume and high variety by the adoption of traditional manufacturing processes (Berry and Hill, 1992). Job shop, for instance, can achieve high variety but at low volume because this process requires high customisation and therefore, takes longer to complete for each product.

To achieve high volume in a relatively short time, mass production is adopted but this process is very limited in the range of products it can offer. Existing manufacturing processes are thus, inadequate to fulfil the nature of the flight catering business; where volume and variety are to be achieved simultaneously. The concept of mass customisation, on the other hand, is a combination of job shop and mass production, which allows high volume and high variety to be achieved without any trade offs. Since the flight catering industry is highly characterised by high volume and high variety, it lends itself potentially to mass customisation. In fact, it could be argued that the industry has already unknowingly adopted some aspects of mass customisation, such as modularity, in its flight catering operations. This research study therefore, investigates the policies and practise of mass customisation and the extent to which these have been applied in current flight catering operations.
1.2 Research rationale

Many studies had investigated applications of mass customisation in a wide range of industries - for examples, the car rental company, Hertz (Gilmore and Pine, 1997) Regent Hotel, Hong Kong (Mok et al., 2000) and computer manufacturer, Dell (Magreta, 1998). This study intends to focus on one single industry in some depth in order to investigate two specific issues. First the study will seek to understand how the concept of mass customisation may be implemented in the flight catering industry, and the current flight catering operational processes in relation to mass customisation. Second, the study will seek to identify specific mass customisation polices and practices in current flight catering operations and determine the elements that lead to improved efficiency as compared to other inefficient flight catering units. The undertaking of the second task of this study is rather ambitious, since to begin with, there are no published articles that look at the efficiency of the flight catering industry. As explained by the 'Theory of Performance Frontiers' (Schmenner and Swink, 1998), the adoption of certain policies and strategies to better the performance of a company, could shift its efficiency frontier. It is proposed that the adoption of a mass customisation strategy would lead to a shift in the operating frontier of flight catering companies.

The flight catering industry has been selected as the sector of analysis for a number of reasons. First the industry inherently has characteristics in terms of the volume and variety of output that make mass customisation a highly desirable strategy to adopt. This is further explained in section 3.13 of Chapter 3. Second, there is prima facie evidence to suggest that mass customisation, or elements of mass customisation, have been and are being implemented in the industry (see in section 4.5 of Chapter 4). This is being driven by the very competitive nature of the industry following a significant shift in industry concentration and growth of low cost airlines. Finally, there is the pragmatic...
Chapter 1 Introduction

reason for selecting this industry which derives from the strong links between the
University of Surrey and the International Travel Catering Association (ITCA), who
sponsor a chair in the School of Management. This link suggests that access to data may
be facilitated thereby allowing the objectives proposed in this study to be achieved.

1.3 Research questions

The research questions that led to the investigations of this study are:

- Does mass customisation already exist in current flight catering operations?
- What are the current MC practices adopted in the flight catering operations?
- How are MC practices related to elements that constitute the MC strategy
discussed in existing published literatures?
- What are the MC practices that led to one flight catering company being more
efficient than another?

1.4 Aim of the study

This study has investigated the operational processes of the flight catering industry in
relation to MC, and determines the MC mode for this industry. Mass customisation may
play an important role in improving the performance of flight catering operations and
this study intends to identify MC elements that may lead to improved efficiency for
units that have adopted the implementations of MC.

1.5 Research objectives

In order for these aims to be reached, a set of objectives were developed and outlined as
follows:
• To understand current flight catering unit operations and processes in relation to MC, and identify the MC mode of this industry according to the five fundamental MC modes proposed by MacCarthy et al. (2003).
• To measure and differentiate operational efficiencies of flight catering using DEA
• To identify and understand similarities and differences in these units
• To identify the policies and processes implemented in flight catering units that could lead to improved performance and mass customization.

1.6 Methodological summary
To address the research aim, the methodology is used to both explore and describe operational processes in the flight catering industry in relation to MC; and reveal the influences and elements in the efficient flight units compared to inefficient units. A combination of qualitative and quantitative approach as are utilised, forming a triangulation of methods that can ensure validity of the method used for the investigation. In the exploratory study (Stage One) secondary data, on-site observation and interviews were adopted to conceptualise the nature of operations processes in flight catering. For the main study, a quantitative approach was adopted, Data Envelopment Analysis (DEA), to identify efficient and inefficient flight catering units in Phase I. Subsequently in Phase II, qualitative case studies on the efficient and inefficient units were developed, based on protocol interviews, observation, audits and other on-site data collection methods. In particular, the research design seeks to determine and understand important factors (inputs and outputs) in the operational process that have significant contribution to the performance of the flight catering industry.
1.7 Structure of the thesis

This thesis is structured into ten chapters; this chapter has begun with a brief introduction to the nature of the proposed study. The aim and objectives of the research have been stated. The structure of the thesis is outlined in Figure 1.1 as follows:

**Figure 1.1 Outline of process structure in this thesis**

- **Literature review**
  - Type of Operations (Chapter 2)
  - Performance Frontiers (Chapter 2)
  - Mass Customisation (Chapter 3)
  - Trends in Flight Catering (Chapter 4)
- **Research Objectives**
  - Research Questions
  - Hypothesis Development
  - Research Boundaries
- **Methodology and Empirical Research Design** (Chapter 5)
  - Generating the Theoretical Framework
  - Defining Variables in the Flight Catering Industry
- **Data Collection, Analysis and Interpretation**
- **Stage One: Exploratory Study**
  - Current Flight Catering Operations in Relation to MC Mode (Chapter 6)
- **Stage Two: Main Study**
  - Phase I - DEA Quantitative Data Analysis (Chapter 7)
  - Phase II - Findings of Case Studies (Chapter 8)
- **Discussion of Results** (Chapter 9)
  - Form Conclusion, Guidance for Future Research and Recommendations (Chapter 10)
Following the introductory chapter, Chapter 2 reviews the literature on operations management especially the concept of ‘process choice’, Theory of Swift and Even Flow and the Theory of Performance Frontiers. The main conceptual frameworks and theories that underpin operations management are introduced and explained. In addition, the nature of two important types of operation - the job shop and mass production are examined. In addition, the concept of Just-In-Time, lean production, and types of flexibility are also discussed. Attention is give to the factors that influence the success of MC implementation.

Chapter 3 explores how mass customisation has evolved from these into a new form of operation. Alternative approaches to defining and explaining mass customisation are reviewed and compared. The basic framework of mass customisation is further developed by MacCarthy et al. (2003) that result in five fundamental mass customisation operational modes which are discussed in this chapter.

Chapter 4 introduces the flight catering industry and identifies the nature of operational processes in a typical flight production unit. Potential for adopting mass customisation in the flight catering industry and the characteristics in this industry can be identified. Future trends in the flight catering industry are also identified in this chapter.

Chapter 5 addresses and explains the research design and methodology adopted in the study. In consideration of the type of methodologies to be adopted for the investigation of the study, quantitative and qualitative methodologies are first reviewed, highlighting the relative advantages and disadvantages of each. This chapter then proposes the research design and the research methodologies to be adopted at the different stages of the study.
Chapter 6 analyses the data collected from all methods employed at Stage 1. The data is collected from three alternative sources: text books and trade publications as well as observational studies of six flight kitchens in United Kingdom and through structured interviews with managers in the flight catering industry at the International Travel Catering Association trade show in Nice, France. The findings at this stage are reported.

Chapter 7 describes the data collection process for DEA analysis and also identifies two efficient and two inefficient flight catering units for further in-depth case study investigations to understand the effects of MC elements on operational efficiency.

Chapter 8 primarily presents detailed descriptions of the operations in the four flight catering units used as case studies. Using the methods of within-case and cross-case analysis, the data gathered from the interviews and observations is examined and compared.

Chapter 9 discusses the implications of the findings presented in Chapters 6, 7, 8, as well as stages developed within the methodology in Chapter 5 and makes a comparison with the previous literature reviews noted in chapters 2, 3 and 4 is to relate the operational processes described in Chapter 8 to specific MC elements.

Last but not least, Chapter 10 summaries the findings of the whole study and outlines the contributions this study has offered. The limitations affecting the study are presented and recommendations for future research are provided, that can be undertaken to further investigate the operational efficiency of the flight catering industry due to specific MC elements.
Chapter 2 Operations Management and Types of Operation

2.1 Introduction

Recognised as vital to the prospects of any company, operations management needs to be judiciously approached. Therefore, this chapter begins with the definition of operations management. The main conceptual frameworks and theories (Theory of Swift and Even Flow and Theory of Performance Frontiers) that underpin operations management are then introduced and explained. Following this, an evolution of processes from the craft era (job shop) to mass production era and then to the most recent era of mass customisation are discussed. Job shop operation and mass production are two common manufacturing practices each with different characteristics. Job shop operations can produce a wide variety of products but restrict the amount that can be manufactured. Mass production, on the other hand, can achieve high volume but typically limit the number of variety of products.

The chapter concludes with a review of current trends in operations management, focusing on those which may be relevant to the emergence of mass customisation. Functional flexibility enables organisations to respond more flexibly to future changes and help the employer to reduce labour costs and improve organizational efficiency and productivity. Flexible manufacturing system (FMS), a computerised manufacturing system to dynamically produce variety of high-precision parts, can lower capital investment, reduce direct labour costs, add part variety, increase machine utilization and decrease work-in process inventory, and raise production output (Cariapa, 1991). The FMS can achieve high levels of efficiency for producing small and mid-volume batch sizes (Chang et al., 1986). Finally the concept of lean production and JIT is discussed.
2.2 Definitions of operations management

The term operations management was probably first used by Elwood Buffa in the 1960s as a synonym for production management (Martin, 1997). Heizer and Render (1992:2) stated that 'Production management and operations management are activities which relate to the creation of goods and services through the transformation of inputs into outputs'. In addition, Hill (1993) perceived production management and operations management as the management of resources required to produce services or products to customers.

Consequently, in the broadest sense, there is agreement that operations management is concerned with producing a product or a service. To sum up, operations management is concerned with the task of managing the process (or system) for the production of goods and services from the input resources which usually include labour, plant and machinery, materials and information (Johnson et al., 1972; Wild, 1980; Muhlemann et al., 1992; Johnston et al., 1993; Schroeder, 1993).

2.3 Operations management theory

It has been argued that operations management is atheoretical (Schmenner and Swink, 1998). Certainly until the early 2000s, that theory has not been well articulated however, a number of conceptual frameworks and theories have been proposed. Hayes and Wheelwright (1979) developed a key framework, in which the concept of process type and the concept of process layout were link. The underpinning rationale for this is developed by Schmenner and Swink (1998) as the 'Theory of Swift and Even Flow', along with their 'Theory of Performance Frontiers'. As it is these theories that underpin this research study, each of these will now be explained in more detail.
2.3.1 Product/process life cycle

The traditional product life cycle concept focuses on market implications, but industries may find it too simplistic to use in strategic planning. Hayes and Wheelwright (1979) suggested that the product life cycle may also facilitate the understanding of the strategic options available to a company, particularly with regard to its manufacturing function. Based on their theory, as product markets pass through a series of major stages, so do the production processes used in the manufacture of the product. The process evolution typically begins with a ‘fluid process’ and proceeds toward increasing standardisation, mechanisation, and automation, and finally culminates in a ‘system process’. The fluid process is one that is highly flexible, but not very cost efficient. Contrary to the fluid process, the system process is very efficient but much more capital intensive. Thus the final evolution “system process” is less flexible than the original “fluid process”.

Figure 2.1 represents the interaction of both the product and process life cycle stages. The rows of the matrix represent the major stages through which a production process tends to pass from the fluid form in the top row to the system form in the bottom row. The columns represent the product life cycle phases from the great variety associated with start-up on the left-hand side to standardised commodity products on the right-hand side (Hayes and Wheelwright, 1979). Three issues arise from the product-process life cycle:

1. The concept of distinctive competence. It permits a company to be more precise about what its distinctive competence really is and to concentrate its attentions on a restricted set of process decisions and alternatives, as well as a restricted set of marketing alternatives.
2. The management implications of selecting a particular product-process combination in relation to the competition. As a company moves toward more standardised processes, the competitive emphasis generally shifts from flexibility and quality to reliability, predictability, and cost.

3. The organising of different operating units so that they can specialise on separate portions of the total manufacturing task while still maintaining overall coordination. Recognising the impact that the company’s position on the matrix has on these important tasks will often suggest changes in various aspects of the policies and the procedures the company uses in managing its manufacturing function, particularly in its manufacturing control system.
According to Hayes and Wheelwright (1979) the matrix can also be useful for determining the appropriate mix of manufacturing facilities, identifying the key manufacturing objects for each plant, monitoring progress on the those objectives at the corporate level, reviewing investment decisions for plant and equipment, determining the decision and timing of major changes in a company’s production processes, evaluating the product and market opportunities, selecting an appropriate process and
product structure for entry into a new market. As well as applying Hayes & Wheelwright Process-Product to manufacturing industry, service products and processes can also utilise this matrix to improve efficiency. Buffa (1976) proposed service classification schemes analogous to the manufacturing processes within the Hayes & Wheelwright Process-Product Matrix.

Subsequently, this approach has been simplified with product structure being termed “volume” and process structure as “variety”, in order to develop a taxonomy of process types (see also section 2.4). This has lead to manufacturing being classified into five types: project, job shop, batch, mass and continuous processing. Also, services have been classified as three types: professional services, mass service and service shops (Silvestro et al., 1992). Polito and Watson (2004) also discussed process-product diagonal of the matrix to facilitate improvement of services.

2.3.2 The Theory of Swift and Even Flow

The Theory of Swift and Even Flow addresses the phenomenon of cross-factory productivity differences. Schmenner and Swink (1998) stated that this theory holds the rule that the more swift the flow of material through the process, the more productive the process is.

The Theory of Swift, Even Flow can refine the understanding of the product-process matrix, as illustrated in Figure 2.2. If the horizontal axis of Figure 2.1 is replaced by high and low demand variability, and the vertical axis is substituted by high and low speed of flow, then a new diagonal can be seen. Such redefinition of the
product-process matrix is quite consistent with the thrust of the Hayes and Wheelwright framework (Schmenner and Swink, 1998).

**Figure 2.2 Process types based on Theory of Swift and Even Flow**

(Schmenner and Swink 1998:106)


- Law of variability - Schmenner and Swink (1998:101) believed 'the greater the random variability, either demanded of the process or inherent in the process itself or the items processed, the less productive the process is'. Hence according to this law, flow process operations are the most efficient type of operation and projects are the least efficient.
Chapter 2 Operations Management and Types of Operation

- Law of bottleneck - productivity is improved if the rate of flow is consistent throughout the whole process by eliminating or by better managing its bottleneck.
- Law of scientific methods - labour productivity is improved by applying scientific management principles.
- Law of quality - productivity improves as quality improves since waste is eliminated, either by changes in product design, or by changes in materials or processing.
- Law of factory focus - factories that perform a limited number of tasks will be more productive than similar factories with a board range of tasks.
- Law of prioritisation - in operations of inherent instability, the greater the instability the greater the prioritisation of orders (Westbrook, 1994)

In summary, the Theory of Swift and Even Flow expounds that the higher the variability and personal demand of goods and services are, the lower the productivity is.

2.3.3 The Theory of Performance Frontiers

The Theory of Performance Frontiers addresses the multiple dimensions of factory performance and seeks to unify prior statements regarding cumulative capabilities and trade-offs. Schmenner and Swink (1998) used a production function or performance frontier curve to illustrate the “Theory of Performance Frontiers”. This production function methodology includes “the maximum output that can be produced from any given set of inputs, given technical considerations”. In Schmenner and Swink’s opinion, the inputs including “all dimensions of manufacturing performance” and technical consideration defining as all choices affecting the design and operation of the
manufacturing unit. Because this theory is concerned with the reason why some processes are more effective and efficient than others, Brown et al. (2000) renamed it the theory of “process improvement and superiority”. Within the theory there are a number of “laws”:

- Law of trade-offs - manufacturing plant can not provide product of high quality and flexibility, and simultaneously deliver it at the lowest manufacturing costs.
- Law of cumulative capability - an improvement in one manufacturing capability (e.g. quality) leads to improvements in others (e.g. flexibility). Although it seems contrary to the law of trade-offs, Schmenner and Swink (1998) still believed that they are complementary. The law of trade-offs is reflected in comparisons across plants at a given point in time, whereas the law of cumulative capability is reflected in improvement within individual plants over time.
- Law of diminishing returns - as improvement (or betterment) moves a manufacturing plant nearer and nearer to its operating frontier (or its asset frontier), more and more resources must be expended in order to achieve each additional increment of benefit. Law of diminishing synergy - according to the law of cumulative capability, the strength of the synergistic effects diminishes as a manufacturing plant approaches its asset frontier.

Brown et al. (2000)

Operating frontiers and asset frontiers have a distinction between each other. The “Operating Frontier” represents operational activities within a given set of assets and it models the most effective and efficient use of the inputs; whilst the “asset frontier”
reflects the infrastructural elements or asset utilisation of the operations and it models the best design and configuration of the transformation inputs.

According to Schmenner and Swink's theories (1998), a plant may improve its operational performance in two different ways - "improvement" and "betterment". In Figure 2.3, plant A is under-utilised and inefficient. Rationalising resources and resolving inefficiencies leads to position A1 at which the plant encounters its operating performance frontier. Schmenner and Swink termed this as "improvement". Operating policy changes shift the frontier and move the plant to A2, where technological and asset constraints begin to significantly affect performance. This shift is termed as "betterment" by Schmenner and Swink. It can be achieved by adopting new and different policies and strategies, such as just-in-time (JIT), total quality management (TQM) and mass customisation (MC).

Figure 2.3 "Improvement" and "betterment" of performance

(Schmenner and Swink, 1998:109)
In this study, flight catering operations are researched to investigate if they have achieved both improvement and betterment. It will be argued that improvement derives from changing some policies and procedures whereas betterment derives from adopting a combination of policies and procedures that together make up the mass customisation strategy.

2.3.3.1 Efficiency frontier from economics

The concept of the Theory of Performance Frontiers discussed in the previous section was actually borrowed from economics, which termed performance frontier as efficiency frontier. The pioneer of the efficiency frontier approach is Farrell (1957). He proposed nonparametric methods of efficiency measurement which demonstrate two forms of productive efficiency at firm level: technical (production) efficiency and allocative (price) efficiency. The first defines the production frontier, which measures the firm's success in producing maximum output from a given set of inputs. The second defines the allocative efficiency, which measures a firm's success in choosing an optimal set of inputs and outputs with a given set of competitive market prices (Sengupta, 1999).

The efficiency frontier of Farrell's approach is made up of coordinate points of observed input and output values from the most efficient units. These points are linked in the piecewise linear fashion to form a frontier. Each frontier point is defined as a linear combination of adjacent, linearly independent frontier observations (Bessent, 1988). The efficiency frontier, as the standard, is defined as the minimum unit-output-input requirement. Farrell was more concerned with the observed standard than the theoretical one. Therefore, the productive efficiency is defined, in Farrell's (1957) approach, as the comparison of the performance of actual establishments with
the best-practice standard observed or frontier production function, rather than taking
the theoretical standard as the point of reference.

According to Farrell's theory, the term "efficiency" is defined by economists in two
main contexts: whether or not a good or service is provided up to the point where the
marginal benefit equals the marginal cost (allocative efficiency), and whether or not the
good or service is produced at least cost. Least cost requires both technical (or
productive) efficiency and input price efficiency (Lovell, 1993:14).

2.3.3.2 Data Envelopment Analysis and the Theory of Performance Frontiers
For this study, the assessment of performance frontiers of different companies was
performed using 'Data Envelopment Analysis' (DEA). The relevance between the
methodology of DEA and the Theory of Performance Frontiers is discussed in this
section.

The concept of DEA was first introduced by Charnes et al. (1978) to evaluate nonprofit
and public sector organizations. Subsequently, the DEA is found to be a valuable tool
for a variety of corporate service organizations. As a multivariate, non-parametric
technique, DEA benchmarks units by comparing their ratios of multiple inputs to
multiple outputs, and by using the concept of performance frontier (Avkiran, 1999a). In
addition, DEA constructs an efficiency frontier that represents the minimum costs
necessary for a firm to achieve a given level of output. Any input utilization greater than
this minimum amount is deemed excess and the firm is classified as inefficient
(Anderson, 2000). Furthermore, DEA (Banker et al., 1984) requires only an assumption
of convexity of the production technology, and employs the postulate of minimum
extrapolation from observed data to estimate production correspondences. Unlike the classical econometric production function, it floats different piecewise-linear surfaces in different segments of the production technology.

Evidently, DEA reflects a close relation to the Theory of Performance Frontiers. Recalling the definition by Schmenner and Swink, a performance frontier in the context of operations management, is the maximum performance that can be achieved by a manufacturing unit given a set of operating choices. Hence, DEA can map out an efficiency/productivity frontier that closely resembles the performance frontier defined by Schmenner and Swink.

2.4 Basic process choices

This section identifies the basic operation processes that have existed in industries for years and can be found in any industry. Each process will be explained along with examples of industries that implement them. In 1979, Hayes and Wheelwright identified that there were a number of basic processes that manufacturers engaged in. Based on Hayes and Wheelwright’s analysis, Berry and Hill (1992) showed how these process choices for companies meet the needs of different markets (Figure 2.5). Companies typically select a process to reflect order winners (manufacturing capabilities, examples price and delivery speed) and anticipated volume (e.g. A1 and B1 in Figure 2.4) followed by the associate point on the numerous business dimensions and investments (see A2 and B2) (Berry and Hill, 1992).

Different companies have their ideal levels of product volume, costs, product design capacity, and manufacturing standards. They can apply the different manufacturing processes to simply qualify their company in the market. For example, if a company
manufactures a large volume of highly standardised products, it will undertake line or continuous processing. Under this condition, a company’s order qualifying criteria will be design capability, manufacturing flexibility, and delivery speed to complete. However, cost, design conformance, and delivery reliability key will win orders in the marketplace (Newman and Hanna, 1996).

**Figure 2.4 Basic process choices**

(Berry and Hill, 1992:7)

### 2.4.1 Evolution of process types

Over the years, process types have changed and evolved to adapt with the changing demands of the market. Brown et al. (2000) proposed an evolution of the types of
operations. They divided the evolution through three eras - the **craft era**, **mass production era** and **mass customisation era**. According to their explanation:

- **The craft era** - is the period of the artisan making customised goods as a blacksmith making a chisel or hoe for a farmer to use. This operation type is handicraft and has unique product. Every craftsman usually works in the context of their own small business.

- **Mass production** - is the period of large scale production of relatively standard outputs. The volume of product is large and multiple. Manufacturing speed is fast and the average cost of each product is low. The growth of large firms and organisations to fit the economies of scale is the characteristic of this era.

- **Mass customisation** - is the period combines the craft and mass production era to produce customised goods in large scale. This era is the modern day. It can satisfy the customer demand and fit the advantage of large-scale production.

Brown et al. (2000) also identified eight separate operational types. Figure 2.6 shows the basic types of operation under each era. The **simple project**, **job shop**, and **batch process** are the three basic forms that existed during the craft era and may continue today. **Complex project**, **batch production**, **assembly line** and **flow process** are the four basic operation types of the mass production era, also in existence today. Finally, **mass customisation** reflects contemporary practice in some industries and is the goal of many enterprises (Figure 2.5). Below are their detailed descriptions of each form.

**Simple project** - it is defined as a craftsman, group of artisans or skilled professional workers to produce a unique output. Many handicrafts, manpower and service businesses belong to this category. Brown et al. (2000) illustrated that house
construction, bridge building, works of art and hairdressing are examples of this form. Most simple projects are mainly materials processing or customer processing operations.

**Job shop** - it is manufacturing units that utilise diverse workstation types in various sequences to process a variety of individual products. The authors utilised blacksmith's forge, auto repair shops, a la carte restaurants, traditional forms of education, general practice in medicine, jeweller marking, bus and air transportation as the examples of job shop. The job shop can process customers, material or information.

**Figure 2.5 Evolution of eight operational types**

(Jones 2001:3)
**Batch process** - the distinguishing feature of this form is the treatment of raw materials. Natural materials like wood, oil, etc. are processed on a continuous process basis into finished products. There is no service aspect involved in this form. The main examples are in the area of pharmaceuticals and chemicals.

**Complex projects** - unlike simple project form of craft era, this project is larger and more complex. The availability of entirely new materials, the mechanisation of some elements of the activity and the development of special expertise are the three main influential factors. Large-scale bridge building and a large theme amusement park establishment are examples of complex projects.

**Batch production** - it derived from the job shop and is sometimes referred to as a “standardised job shop”. It includes mechanisation of elements of the production process, division of labour and work simplification, along with some interchangeable parts. Some components can be used in the production of more than one product. Examples of this type of operation are printing shops, package holidays, fast food restaurants and conventional classroom based education.

**Assembly line** - with the addition of the moving production line or the customer replacement of the production worker in service into mechanisation, division of labour, and interchangeable parts make up this type of operation. Vegetable canners, meat wholesales and computer manufacturing, automated banking services are examples of this type of operation.
Flow process - this is the most continuous production of commodity products. Paper, beer, oil and steel production are typical examples of this type. Development of new materials, scientific discoveries and mechanisation all influence this operation.

Mass customisation - mass customisation is also the design, production, marketing, and delivery of customised products and services on a mass basis. By using advanced information and production technologies, mass customisation requires the customer and business to develop the product or service together so as to provide customers with the exact product they want on time (Davis, 1987; Pine, 1993). The process is agile (the ability to alter any aspect of the manufacturing enterprise in response to changing market demands) and the output is flexible (the ability to deliver high quality products tailored to each customer at mass production price). Examples of this type of operation are automobile manufacture, book retail, shoe industries, and computer manufacturer. This process type is discussed in more detail in the next chapter.

From analysis of these operation types, some important points emerge. Some industries may operate only in one era, however, some may span two or three eras. For example, the automobile industries consist of craft car manufacturers (such as Morgan), mass produced car enterprises (Ford, General Motors) and mass customisation producers (BMW). Even the same company may utilise operations across different era and apply separate operation processes. Since mass customisation derives from both the job shop operations and mass production, each of these two process types will now be discussed in more detail.
2.5 Job shop operations

Job shops are manufacturing units that utilise diverse workstations in a variety of sequences to process a range of individual products. The requirements of any particular product are different to each other, so no dominant flow patterns may be readily visible in the operation. Product volume is not high enough to economically set up a production line for any one-product type (Montreuil et al., 1999). Another important characteristic of a job shop is the variability in job demand and a constantly changing product mix. Therefore, the system should be inherently flexible and can respond to variations in the environment (Benjafar, 1992). Pettit (1968) defined the job shop as having the following characteristics:

- There is a set of production or service facilities.
- Jobs consisting of several tasks move among facilities for service.
- One or more tasks are performed at each facility.
- The service time for tasks may vary from job to job.
- The routing between facilities may vary from job to job.

2.6 Mass production

After the Industrial Revolution (1770-1800), mass production emerged in the nineteenth century (Duguay et al., 1997). The basic characteristics of mass production were the division of labour, interchangeable parts, assembly line layout and mechanization. However, complexity, organisation, coordination, and control problems led to “scientific management” (Chandler, 1977). Scientific management focused on the systematic organisation of work in order to make-work easier to manage. Frederick W. Taylor (1865-1915) was the pioneer and chief artisan. Both planning departments
and greater fragmentation of tasks arose from Taylor’s analyses. Production of the Ford Model T (1908-1927) early in this century is certainly the most famous and one of the most strikingly successful examples of mass production (Hounshell, 1984). Initially it took 14 hours to assemble a Model T car. By improving the mass production methods, Ford reduced this to 1 hour 33 minutes. This lowered the overall cost of each car and enabled Ford to undercut the price of other cars on the market. Between 1908 and 1916 the selling price of the Model T fell from $1,000 to $360. Following to the success of Ford's low-price cars, other companies began introducing mass production methods to produce cheaper goods. This paradigm emphasises vertical integration, standardisation, economies of scale and was the mindset that permeated American manufacturing until the 1960s (Pine, 1993).

During the Second World War, US industry was remarkably successful in converting its production system to military applications. They also joined forces with scientific researchers to perfect rapidly relatively new products and subsequently to produce in large volumes (Hayes et al., 1988).

2.7 Modern trends and concepts in operations management

As mentioned in the introduction of this chapter, flexibility is an important concept in operations management and may be an important enabler of mass customisation (as discussed in the next Chapter). In order to enhance competitiveness, many firms have developed different methods of adapting the business, due to the climate of rapid technological change. Flexibility is a multi-dimensional construct representing labour, technology, management and land (Blunsdon, 1995) that can response to pressure and adapt to change (Blyton, 1992). Flexibility issues range from changes in work practices
to production strategies, manpower re-deployment, labour market structure and organizational control. A second key concept is "lean" production.

2.7.1 Labour flexibility

Labour flexibility is one of many aspects of flexibility (Chow, 1998). It can be applied to all levels of operations and when applied successfully can result in improvements i.e. enable a firm to remove inefficiencies through the law of cumulative capability. There are several different types of labour flexibility. One approach to employment flexibility identifies four broad categories: numerical flexibility, functional flexibility, distancing, and pay flexibility (Olmsted and Smith, 1989; Pinfield and Atkinson, 1988) Numerical flexibility refers to adjustments in the number of workers or the working hours in line with variation in demand. Functional, or internal, flexibility allows workers to be reassigned to different tasks across job boundaries according to demand (Mutari and Figart, 1997). Distancing strategies outsourced labour and shift the burden of risk and uncertainty elsewhere (Riley and Lockwood, 1997). Pay flexibility adjusts pay structures in line with changes in economic and competitive conditions (Rix et al., 1999). Firms use these types of employment flexibility in different dimensions depending on their specific competitive circumstances (Pinfield and Atkinson, 1988).

The advantages of flexibility include:

- Functional flexibility enables organisations to respond more flexibly to future changes (Atkinson, 1984: 28).
- The employer can obtain a good recruiting tool to reduce labour costs and improve organizational efficiency and productivity (Friedrich, 1998).
- The supervisory personnel reduces and may lead to a reduction in indirect labour costs (Friedrich, 1998).
Functional flexibility is often associated with different models of work systems such as job enlargement, job enrichment, job rotation, and semi-autonomous work groups (Cordery et al., 1993:705). By extending the content of work and adding several successive work steps, expanding the field of activity is called job enlargement, which emphasizes on quantity. Comparatively, job enrichment pays more attention to the qualitative aspect. The scope of activity is expanded by enriching the tasks with functions of decision-making, powers planning and controlling. In addition, the scope is often accompanied by the conferring of more complex and high quality tasks (Friedrich, 1998). Job rotation implies the change of workplace by transferring employees between various areas of responsibility. This flexibility can enhance employees’ knowledge and abilities and exercise functions independently and responsibly.

Friedrich (1988) surveyed European organisations and concludes that functional flexibility is a possible way of turning away from traditional career planning in the framework of lean management aspirations. It is a component of strategic oriented human resource management in the sense of a co-ordinated, objective oriented personnel management pattern and less of a short-term economic and reactive instrument. However, the flexible factory must rely on planning and training because the flexibility is caused by production changes rather than direct market intervention (Mair, 1994). That is to say that companies can take over these new functions and tasks temporarily or possibly simultaneously and, on the other hand, these methods-also can enhance the effectiveness of management.
The next section compares production using the concept of flexibility with the traditional production, and highlights the importance of adapting to the environment through flexibility in operations.

2.7.2 Flexible manufacturing system

Flexibility is the objective of numerous manufacturing technologies coping with changing circumstances. Demand flexibility, market flexibility, mix flexibility, product flexibility, production flexibility, and volume flexibility are examples of various flexibility types which are used to define the extent to which manufacturing firms can cope with changes in their environment (Shewchuk and Moodie, 2000). Other similar classification includes eight types of flexibilities: machine, process, product, routing, volume, expansion, operation and production (Browne et al., 1984).

The original concept of the flexible manufacturing system (FMS), also termed computer-managed parts manufacturing (CMPM), has emerged in the mid-1960s with the Ingersoll-Rand facility in Roanoke, Virginia, USA. It attempts to achieve both production flexibility and high productivity in order to meet the demands of today’s competitive markets (MacCarthy and Liu, 1993). Flexible manufacturing system offers the hope of eliminating many of the weaknesses of the other approaches but possibly at a cost of cutting out many jobs (Aggarwal, 1985).

Chang et al. (1986) described that an FMS is a computerised manufacturing system which combines numerical control (NC) machines with an automated material handling system to produce dynamically a variety of high-precision parts. Byrkett et al. (1988) stated that a FMS is a manufacturing system in which groups of numerically controlled machines (machine centers) and a material handling system work together under
computer control. Kaltwasser et al. (1986) explained the FMS on the capability or performance that FMS are highly automated production systems, able to produce a great variety of different parts by using the same equipment and the same control system. MacCarthy and Liu (1993) believed that FMS contains three subsystems:

- A processing system: these elements, enable the FMS to process different types of product concurrently, are a group of numerically controlled (NC) or computer numerically controlled (CNC) machines with tool changing capability.
- A material handling and storage system: these elements, provide flexibility of part movement, are buffer stores and material handling equipment such as robots, automated guided vehicles (AGVs) and conveyors.
- A computer control system: this controls the operations of the whole system.

Co (2001) has the most complete description of FMS - a typical FMS utilizing a computer numerical-control technology in the automated material-transfer system linking several programmable machines, being supplemented by auxiliary workstations, to process a wide variety of parts concurrently.

Among the various classifications, generally, the FMS is classified into two broad categories. A random FMS employs a set of general-purpose machines, an automated material handling system, modular pallet fixtures, and an automated tool loading system. It is capable of producing a large family of widely differing parts. The product mix is not completely specified and the production schedule is subject to frequent changes (Denzler and Boc, 1987). The random FMS is the equivalent of the job-shop in conventional production and intend for flexible production in high-variety, low-volume situations.
On the other hand, a dedicated FMS employs a set of general or special purpose machines with which a set of tools are fixed, an automated material handling system, part specific pallet fixtures and magazines. It produces a small family of processing requirements (Denzler and Boe, 1987). The dedicated FMS is intended for economic lot-size production in mid-variety, mid-volume situations, typically found in a material requirements planning (MRP) environment (Co, et al., 1995). Limiting the variety of parts such as minimizing bottlenecks caused by delays in data communication and processing, maximizing pooling of machines and added protection against tool breakage, and streamlining the material flow, thus simplifying production planning will ultimately lead random FMS to a dedicated FMS situation (Co, 1990).

One central aspect of flexible production is that any work team can complete any job, from start to finish with the participation of multi-skilled workers. Co (2001) proposed that machines in FMS are analogous to the multi-skilled workers in lean production, unlike specialized workers in mass production. He argues that the FMS is not a network of machines, rather as a system of one or more configurable manufacturing units (CMUs). Each team works on one job at a time from start to finish and jobs are not passed around from team to team, and each configurable manufacturing unit is assigned to a single part type at a time and parts do not have to move in a job shop manner (Co, 2001). In addition, parts are grouped into families, and a number of machines are assigned permanently to process each family of part in mass production. However, in CMU the machines are assigned not permanently, but dynamically as need arises. At the completion of each job, the machines are reassigned to another CMU.
The advantages of FMS over conventional production facilities which use stand-alone computer controlled machines, are lower capital investment (Haas, 1985), lower direct labour costs (Hatvany et al., 1983; Cutkosy et al., 1984), greater part variety, higher machine utilization, lower work-in process inventory, and greater production output (Cariapa, 1991). The FMS can achieve high levels of efficiency for producing small and mid-volume batch sizes (Chang et al., 1986).

2.7.3 Mass production versus agile/flexible production

Today’s most successful industries response to challenge through rapid adapting to the environment instead of isolating themselves or seeking protection. Flexibility/agility is the hallmark of the ability to adapt rapidly and efficiently. Agility means being able to reconfigure operations, processes, and business relationships efficiently while at the same time flourishing in an environment of continuous change (Hormozi, 2001). Flexibility is the capacity to deploy or redeploy production resources efficiently as required by changes in the environment. Duguay et al. (1997) compared the main traits of the mass production paradigm with the flexible production paradigm (as summarised in Table 2.1). They argue that the primary objective of mass production is lower cost; however the flexible/agile production reduces costs by improvement of three broad cross-functional factors (quality, time, and cost).

Mass production focus on process specialisation to reduce production costs. Satisfaction of customers and controlling process to produce quality at the source are the major orientations of flexible/agile production (Goldman et al., 1995). Innovation of mass production is directed by experts and managers to improve the production system. Flexibility/agility production aims basically at introducing innovations as fast as
possible, thus continuous improvement and innovation are prerequisites for agility (Nagel and Bhargava, 1994).

In mass production, the labour is confined to executing production tasks under the supervision of managers. In flexibility/agility production, there are self-organising and self-directed work groups to improve products and working processes (Burgess, 1994). There is an almost adversarial relationship with suppliers in mass production, but there is long-term co-operation partner relation with suppliers to achieve quick response and continuous replenishment in flexibility/agility production (Duguay et al., 1997). The mass production organisation structure is mechanistically in proportion to a flexibility/agility production open system organisation appearing as in search of harmonious relations with its environment.

Mass production has a discontinuous technological choice while technological choices of flexibility/agility production are linked to the corporate strategy and are closely co-ordinated with organisational changes to allow the workforce to adapt to the fluctuations of production and other processes (Duguay et al., 1997). Mass production is financial-based performance evaluation. Performance evaluation of flexibility/agility production aims at spurring and sustaining both innovation and continuous improvements (Burgess, 1994).
Table 2.1 Main traits of the mass production paradigm versus flexible production paradigm

<table>
<thead>
<tr>
<th></th>
<th>Mass production Paradigm</th>
<th>Flexible/Agile production Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary objective</td>
<td>Low costs</td>
<td>To improve quality, costs and time simultaneously</td>
</tr>
<tr>
<td>Major orientation</td>
<td>Process</td>
<td>Customers and process</td>
</tr>
<tr>
<td>Favoured means of improvement</td>
<td>Innovation</td>
<td>Continuous improvement and innovation</td>
</tr>
<tr>
<td>Workforce</td>
<td>Work under supervision of managers</td>
<td>Workforce makes the product, identifies and solves problems with the support of managers</td>
</tr>
<tr>
<td>Suppliers</td>
<td>Treated at arm’s length and made to compete against each other</td>
<td>Partners</td>
</tr>
<tr>
<td>Organization structure</td>
<td>Mechanistic</td>
<td>Organic</td>
</tr>
<tr>
<td>Technology</td>
<td>Analytical</td>
<td>Systemic</td>
</tr>
<tr>
<td>Performance evaluation</td>
<td>Financial measures most important</td>
<td>Promotes continuous improvement</td>
</tr>
</tbody>
</table>

(Duguay et al., 1997:1185, 1193)

2.7.4 Just in time and lean production

The system of just-in-time (JIT) was first developed at the Toyota Motor Company two decades ago in Japan. However, JIT has become an effective approach to gaining competitive advantage in manufacturing, by managing activities that leads to achieve efficiency and consistently high product quality. Its lean inventories also allow rapid response to the changing needs of the marketplace (Lee and Seah, 1987; Abdulnour et al., 1995; Ehrhardt, 1998). Further defined by Monden (1993) and Houghton and Portougal (1997) JIT production is

- An integral part of the philosophy and the associated long-term quest for smaller set-up costs, batch sizes and inventories.
• May be achieved by production control systems, like kanbans or by more regular processes of production planning.

• A part of the larger production system, incorporating kanbans, quality circles, multitasking, etc. which is preferably referred to as the Toyota production system.

Though, there is no common definition for JIT, it normally consists of some or all of these elements continuous improvement philosophy, demand - pull production, reductions in machine setting time and changes in supplier relations (Howton et al., 2000). JIT production system is a pull system, where in the processing of a batch of an item type at a certain station requires the withdrawal of a completed batch of the same item type at the preceding station (Monden, 1993). The major goals of JIT are not to maintain a constant rate of usage of all items processed by the line at the different stations, and also to allow the smoothing of the workload at each station on the line (Monden, 1993). JIT is the organizational principle on the basis of which every working activity that must be supplied with the necessary components in the necessary time and in the necessary quantity (Forza, 1996). The following explicitly described the four major components of JIT (Ettkin et al., 1990).

Flexible workers who are more involved in the decision - making process.

• Equipment flexibility, which includes switching to smaller, simpler, more standardized equipment and/or reducing set-up times on existing or new equipment.

• Redesigning plant layout in order to take advantage of product flow and component commonality.
• Closer relationships with vendors. This includes the use of a smaller number of
vendors, longer-period contracts, and the development of a partnership attitude.

Lean is about doing more with less. The term is often used in connection with lean
manufacturing (Womack et al., 1990) to imply a “zero inventory”, JIT approach. In
practice, minimum reasonable inventory (MRI) is a more relevant philosophy
(Grunwald & Fortuin, 1992). Womack et al., (1990) defined the term “lean production”
(LP) as the lean model that requires less stock, less space, less movement of material,
less time to set up the machinery, a smaller workforce, fewer computer systems and
more frugal technology. Significant interest has been shown in recent years in the idea
of “lean manufacturing” and the wider concepts of the “lean enterprise” (Womack &
Jones, 1990). The focus of the lean approach has essentially been on the elimination of
waste or muda. The recent upsurge of lean manufacturing can be traced to the Toyota
Production systems (TPS), with its focus on the reduction and elimination of waste
(Ohno, 1988). As well as responding to the need to be cost effective, this lean
characteristic also constitutes a general principle that inspires a philosophy of
essentiality and which makes every superfluous element seem wasteful.

However, the arguments of LP and JIT have been widely debated. Inman and Mehra
(1993) found evidence to suggest that there are relationship between the operational
success of JIT and the future finical success of the firm while Balakrishnan et al. (1996)
found there is no difference in return on assets for successful JIT adopters and matched
non-adopters. According to Oliver (1994) study, several measures of management
practice provided some support for the lean production model particularly in the area of
process discipline and control; measures of human resource management policy and
work organisation proved less significant. Womack et al. (1990:277) concluded “lean
production combines the best features of both craft production and mass production — “the ability to reduce cost per unit and dramatically and ever more challenging work”

2.8 Conclusion

In this chapter we have identified the nature of operations management and the main types of operation. Two key theories have been identified – the Theory of Swift and Even Flow and the Theory of Performance Frontiers. According to Brown et al. (2000) the origins of mass customisation derive from job shop operations and mass production. The key characteristics of these two types of operation have been identified. Historically, job shops and mass production were seen as two separate alternatives. The former was effective and efficient at making a wide range of goods to order, whereas the latter was designed to make a limited range of goods to stock. Increasingly, it was recognised that markets were demanding not only low cost mass produced goods, but also variety. The concept of mass customisation addresses this issue, and is explained in the next chapter.

Flexibility of operations management to suit the changing environment is also discussed. Key concepts of operations management - Functional flexibility, FMS, JIT, lean production - are clearly defined and explained. They enable organisations to respond more flexibly and improve organizational efficiency and productivity (“improvement”).

It is argued that if mass customisation is a combination of both job shop and mass production – a “hybrid” operation – then it results in a shift in the operating frontier itself (“betterment”). The challenge in reviewing the literature on mass customisation will be to identify those elements that simply lead to improvement (the operation of job
shops or mass production more efficiently), and those that result in betterment (a new kind of operation), as discussed in the next chapter.
Chapter 3 Mass Customisation

3.1 Introduction

In Chapter two, the main traits of mass production and job shop were introduced, along with a discussion of the essence of each operation. According to Brown et al. (2000), a hybrid combination of mass production and job shop operations lead to mass customisation. Therefore, mass customisation is one of the most important consequential parts of operation management, and is to be discussed in this chapter. The concept of mass customisation emerged in the late 1980s. To 2003, there have been more than 2700 articles that discussed the theory of mass customisation (Tseng and Piller, 2003). This chapter attempts to review the general concept of mass customisation derived from different sources over the years.

Despite the diversified conceptual framework on mass customisation, all the literatures were all implying the same thing albeit expressed in different terms. Therefore, a basic framework of mass customisation was formulated on the basis of common features that were explained in these different literatures. From the basic model of mass customisation, characteristics that differ from mass production and job shop are identified and compared. Mass customisation relates to the provision of products or services at reasonably low cost by the adoption of flexible processes. The basic framework of mass customisation is further developed by MacCarthy et al. (2003) that results in five fundamental mass customisation operational modes which are discussed in this chapter.
3.2 General definition of mass customisation

Mass customisation is a term first coined by Davis (1987) to describe a trend towards the production and distribution of individually customised goods and services for a mass market. Davis (1987:169) also mentioned ‘the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously they can be treated individually as in the customized markets of pre-industrial economies’.

Pine (1993) defined mass customisation as a concept in which customers can select, order and receive a specially configured product - often choosing from hundreds of product options - to meet their specific needs. But there is no point to satisfy customers’ requirements by adding complexities in the production process, as this lead to the firm being inefficient. This defeats the purpose of mass customisation which was why Tseng and Jiao (1996) stressed that the objective of mass customisation is to deliver goods and services that meet individual customer’s needs with near mass production efficiency.

Mass customisation offers consumers the best of both worlds. It embodies the desirable qualities from the era of hand production - custom design and individualised service, and retains the most significant gain from the era of mass production - low cost. Mass customisation is concerned about choice; providing consumers with unique end product when, where, and how they want it (Cox and Alm, 1999).

The emphasis of achieving mass customisation at costs relatively close to mass production costs was underlined by Reichwald et al. (2000). They proposed mass customisation could be used to attain increased revenue by the ability to charge premium prices derived from the add on value of a solution that meets the customer’s specific needs. Reichwald et al. (2000) believed the present competitive situation of many industries prevents the company from reacting by a strategy of differentiation. The cost-benefit relation alters because buyers demand relatively high standards of
quality, service, variety and functionality even when the sales price is favourable or, vice versa, suppliers have to meet additional requirements in pricing when a product is marketed differently.

The objective of mass customisation, ultimately, is to produce goods and services for a (relatively) large market which exactly meets the needs of every individual demander with regard to certain product characteristics (differentiation option) at costs roughly corresponding to those of standard mass produced goods (cost option) (Reichwald et al., 2000). In general, mass customisation is a hybrid of mass production and customisation (Pine, 1993; Taylor and Lyon, 1995; Hart, 1995; Martin, 1997; Da Silveria et al., 2001) and the broad definition of mass customisation is to meet individual needs of customers at the lowest possible cost, according to most of the literatures reviewed over the years.

3.3 The need for mass customisation

Due to the ever changing markets and consumer needs, there is a need to find new ways of conducting business to meet these new demands. Mass customisation is touted as a significant strategy to tackle this issue. Mass customisation has become an inevitable successor to mass production and the principal way in which to compete in the future. Pine (1993:6) remarked that: ‘Customers can no longer be lumped together in a huge homogeneous market, but are individuals whose individual wants and needs can be ascertained and fulfilled’. Leading companies have created processes for low-cost, volume production of great variety, and even for individually customised goods and services. He also clearly distinguished between mass production and mass customisation systems. The mass production’s objective is to produce standardised products at an affordable price. In contrast, the goal of mass customisation is to produce
enough variety in products and/or services so that nearly everyone finds exactly what he or she wants at a reasonable price.

As companies realised the need to be customer driven, diversification of products or services will enable companies to grab a share in this customer driven market. Customers' demands are ever changing and make forecasting and stocking of inventories inefficient (Hart, 1995). The traditional method of mass production can no longer cope with the needs of this ever changing market. At the other end of the manufacturing spectrum, job shop is the method used by companies like jewellery manufacturers to specially tailor products to customers' needs. However, this manufacturing strategy faced the difficulty of delivering products to the mass because of the long production times and the complexity of the designing and fabrication processes. Such strategy can no longer meet the requirement of this fast changing market.

3.4 Implications of mass customisation in operations management

A review of the literatures suggests a number of issues regarding mass customisation and in particular its implications for operations management.

The firms must focus on several aspects while developing the mass customisation offering, including logistics, operations, distribution and marketing (Ahlstrom and Westbrook, 1999).

- To successfully employ mass customisation, a strategy is needed for the interactions and interrelationships among various functional aspects inside the firm (Kotha, 1996).
- The advances of manufacturing function are the most important factors in achieving mass customisation (Spira and Pine, 1993).
Chapter 3 Mass Customisation

- The communication is crucial between manufacturer and market for setting up mass customisation (St. John, 1991).
- The link between internal and external flexibility needs to be strong, otherwise the mass customisation offering is likely to be inadequate in market terms or too costly in operation terms (Upton, 1995).
- Services and products are bundled to anticipate and respond to a wide range of customer needs (Chase and Garvin, 1989).
- Factories need to improve information processing to support mass customisation and one particular change in the manufacturing-oriented information systems is to remove the distinction between customer order and production order (Boynton and Victor 1991; Boynton et al., 1993).
- Supply chain management is the most difficult area to implement mass customisation. However, the improvements of in-bound logistics and distribution (the end of logistic chain) can lead to mass customisation successes (Gilmour and Pine, 1997).
- The manufacture of self-customised products is a popular method for achieving mass customisation. Self-customised products do not necessarily have to be customised by the end-users themselves. Manufacturers who undertake the role of customising the product will vary with the industrial structure and technology (Ahlstrom and Westbrook, 1999).

3.5 A basic model of mass customisation

There had been continuous efforts by several authors to formulate the framework of mass customisation (Pine et al., 1993; Spira, 1993; Lampel and Mintzberg, 1996; Gilmore and Pine, 1997; Da Silveria et al., 2001). The idea was to allow all aspects to be considered in the process of customisation: from development to production and finally
Chapter 3 Mass Customisation

to delivery. Hence, different customisations can be produced at any levels of the value chain. The continuous development of the levels for customisation were summarised by Da Silveria et al. (2001). There were eight generic levels of mass customisation ranging from individually designed products to standardisation. Table 3.1 outlined the summary of these eight generic levels.

Table 3.1 Mass customisation generic levels

<table>
<thead>
<tr>
<th>MC generic levels</th>
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</thead>
<tbody>
<tr>
<td>8. Design</td>
</tr>
<tr>
<td>7. Fabrication</td>
</tr>
<tr>
<td>6. Assembly</td>
</tr>
<tr>
<td>5. Additional custom work</td>
</tr>
<tr>
<td>4 Additional services</td>
</tr>
<tr>
<td>3 Package and Distribution</td>
</tr>
<tr>
<td>2 Usage</td>
</tr>
<tr>
<td>1 Standardisation</td>
</tr>
</tbody>
</table>

(Adapted from Da Silveria et al., 2001:3)

- Level 1 - Standardisation is a strategy to eliminate or reduce undesirable variety in the product line; not taking customers’ requirements into considerations. This strategy was common during the mass production era.
- Level 2 - Usage arises when customers can self customise or in other words adjust the functions of products according to situations or for various purposes.
- Level 3 - Mass customisation at the package and distribution stage relates to different ways of delivering and/or presenting similar products and services to individual customers.
- Levels 4 and 5 - Customisation occurs at the point of delivery by providing additional services or custom work to standard products.
• Level 6 - Assembly is concerned with arranging standard components together so as to make up an end product as indicated by the customer’s order.

• Level 7 - Fabrication relates to the creation of customised products based on predefined designs.

• Level 8 - At this stage, customisation involves customers of constructing products and services according to individual preferences.

(Da Silveria et al., 2001)

However, among the eight levels, four levels namely, design, fabrication, assembly and distribution based on the influential work by Lampel and Mintzberg (1996) are the most general steps to any operation process and can be applied to most production settings. In their work, they divided the value chain into four stages - design, fabrication, assembly and distribution. Along this chain, they proposed five strategies that include pure standardisation, segmented standardisation, customised standardisation, tailored customisation and pure customisation.

Pure standardisation means that the customer has no direct influence over the production process. Under segmented standardisation, firms are offering standardised products that have limited range. Customised standardisation implied that the final products are made to order from standardised components. By modifying the standard design of a product in accordance to customer’s needs, the term is known as tailored customisation. In pure customisation, the product is purely made to order at the customer’s request. The generality of the four levels in the value chain discussed by Lampel and Mintzberg (1996) begins to form the most basic framework that explains mass customisation. The next section examines the application of this basic framework
for job shop (customisation), mass production and mass customisation where the differentiating characteristics between the three different operations are revealed.

3.6 Characteristics of job shop, mass production and mass customisation
Despite the diversification on the concept of mass customisation from literatures, there are four generic levels in the value chain (Lampel and Mintzberg, 1996) that really facilitate the explanation of mass customisation and show how it differs from other operation processes. Although job shop (customisation) and mass production have been discussed in the previous chapter, the characteristics of job shop, mass production and mass customisation will be discussed here in accordance to the operational process at each level of the value chain (design, fabrication, assembly and distribution).

3.6.1 Characteristics of job shop
In a job shop operation, the end product is highly customised which means that the product is specially tailored and designed to meet the customer’s requirement. To adhere to the customer’s needs, the design process of a product has to involve customers. A company based on job shop operation will have a variety of individual products with unique parts. The layout design in a job shop environment will be one that locates similar processes in the same place for smooth flow throughout the operation. This kind of layout is known as process layout. Due to the complexity of the design which would involve complex processes to manufacture, fabrication and assembly processes faced the difficulty of being outsourced.

Hence, these two processes are normally finished in-house. The whole process cycle from design to the fabrication of the final product is long. Naturally, the unit cost of the product is inevitably high. Each product is created upon the demand of customers and
therefore, the ever changing wants and needs of customers make the life cycle of a product short. At the distribution stage, the product is packaged and delivered according to the preference of individual customers.

3.6.2 Characteristics of mass production

The objective of mass production is to turn out a large volume of products during a relatively short time. The products are identical with identical parts and no customers are involved in the design. Here, the design of product is all the same or standardised. The layout design of a mass production operation is accomplished by locating all the resources together for convenience. The resources follow a specific route for processing by standardised equipment. This kind of layout is known as product layout. In mass production, fabrication is outsourced and only assembly is completed in-house. The reason is to maintain the speed of operation so that a huge volume of products can be produced. As such, the whole process life cycle of a mass production operation is short. Being able to mass produce in a short time causes the product unit costs to be low. The distribution stage in a mass production environment will be the same for the products. All the products are packaged and delivered in a standardised manner.

3.6.3 Characteristics of mass customisation

Since mass customisation is a hybrid of mass production and job shop, there are certain characteristics in mass customisation that belong to these two. Ultimately, mass customisation aims to produce a variety of products in large quantities. The design of the products requires the interaction with the customer in order to understand their requirements. This is the same as job shop where the product design involves customers. In order to simultaneously meet the needs of variety and volume, parts that are common to different product designs are produced and then assembled to form the
range of different products. In this way, the whole process cycle time can be maintained relatively short.

This is in contrast to job shop which has a longer cycle time because of the complexities in the operation process that requires a lot of time to produce the design. Layout design in a mass customisation environment is modular. In other words, the layout is configured in such a way that groups together common equipment, resources and processes to facilitate the production of modular parts of designs. Products are usually fabricated in-house and assembly of products are mostly outsourced. Like mass production, the unit cost of a product can be relatively low. However, the product life cycle is short which is similar to job shop. The product is delivered and packaged, like job shop, based on the preference of individual customers. A summary of the key characteristics of job shop, mass production and mass customisation is listed below:

Table 3.2 Characteristics of job shop, mass production and mass customisation

<table>
<thead>
<tr>
<th></th>
<th>Design of product</th>
<th>Product/Design of Operation Layout</th>
<th>Fabrication</th>
<th>Assembly</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job Shop</strong></td>
<td>Involve customers</td>
<td>Individual/Unique</td>
<td>Process Layout</td>
<td>In-house</td>
<td>In-house</td>
</tr>
<tr>
<td><strong>Mass Production</strong></td>
<td>Does not involve customers</td>
<td>Individual/Identical</td>
<td>Product Layout</td>
<td>Outsourced</td>
<td>In-house</td>
</tr>
<tr>
<td><strong>Mass Customisation</strong></td>
<td>Involve customers</td>
<td>Individual/Modular</td>
<td>Modular Layout</td>
<td>Some in-house</td>
<td>Not exclusively in-house</td>
</tr>
</tbody>
</table>

(Source: Author)
In summary, Table 3.2 shows that the differentiating characteristics of mass customisation from the other two operations (job shop and mass production) lie in the configuration of the operation layout. This table also shows how parts of designs and processes are modularised to form the groundwork for ease of fabrication and assembly, and finally the ability to assemble the final product before or after distribution.

3.6.4 Trade-offs between different manufacturing processes

In this section, the fact that trade-offs are needed between achieving high volume or high variety of products for the different well established manufacturing processes is reconsidered. More importantly, it is to emphasize that the introduction of the new manufacturing concept of mass customisation, requires no such trade-offs between volume and variety.

Hayes and Wheelwright (1979) explained the trade-offs between the five different manufacturing processes that can produce different variety and volume. Essentially they have trade-offs in doing so. Job shop, for example, can produce a wide variety of products but can only produce them in low volume. In contrast, mass production can produce large quantities of products but low variety.

An extension, adapted from Hayes and Wheelwright’s (1979) trade-offs between volume and variety of the five processes which included the mass customisation process by the author, is shown in Figure 3.1 As shown, mass customisation can achieve high volume while having to cope with variety. As such, unlike the other well established manufacturing concepts, mass customisation requires no trade-offs between achieving high volume and high variety.
3.7 Types of mass customisation

So far the discussion has suggested that mass customisation is a relatively straightforward concept. However, a review of the literature reveals a great deal of confusion with regards the practice of mass customisation. This is specially the case when it comes to different types of mass customisation. Anderson (2003) proposed that there are three ways to customise products: adjustable, dimensional, and modular customisation.

- **Adjustable customisation** - mechanical or electrical adjustments are a reversible way to customise a product. Adjustments could be infinitely variable. Examples include electronic switches, jumpers, and cables. These adjustments and configurations make the product customisable by factory, dealer, or customer.

- **Dimensional customisation** - dimensional customisation involves a permanent cutting-to-fit, mixing, or tailoring and could be infinite or have a selection of
discrete choices. Examples of infinite dimensional customisation are tailoring of
clothings, drilling holes in bowling balls, grinding eyeglasses, mixing of paints or chemicals, machining metal parts, and the cutting of sheet metal, wire, or tubing. An example of discrete dimensional customisation is soldering selected electronic components onto a printed circuit board.

- **Modular Customisation** - modules are literally building blocks that can customise a product by assembling various combinations of modules. Examples of modules are processor boards, power supplies, plug-in integrated circuits, daughter-boards, and disk drives.

Alford et al. (2000) put forward three distinct strategies of customisation - core, optional and form customisation. To illustrate these three strategies, the purchase of a vehicle is taken as an example. In **core customisation**, the customer is involved in the vehicle design process such as low volume specialised vehicles. In optional customisation, the customer is able to choose their vehicles from a very large number of options. In form customisation, customers are able to have limited changes or enhancements made to the actual vehicle which could be dealt with at the dealer or retailer. **Optional customisation** is concerned with the assembly process. The end product depends on how the different modular parts are assembled to form the different product designs which the customer can choose from. As for **form customisation**, it is classified under distribution level where minor customisations are possible at the dealers or retailers end once the products are delivered from manufacturers to them.

In 2001, Zipkin proposed three main elements of mass customisation: **Elicitation** (a mechanism for interacting with the customer and obtaining specific information); **process flexibility** (production technology that fabricates the product according to the
information); and logistics (subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer). Zipkin (2001) emphasised that elicitation, process flexibility and logistics are connected by powerful communications links and thereby integrated into a seamless whole. These three elements have to work well separately. For a mass customisation system to be in practice, they must be linked tightly to form a coherent, integrated whole. Mass customisation systems cross traditional organisational boundaries, particularly those between sales and production. Thus, companies must have organisational agility in addition to technical agility to enable cooperation across those boundaries. Recalling the four generic levels in section 3.5, elicitation is related to the design level. Process flexibility is about flexibility in the fabrication and assembly processes. Lastly, logistics is concerned with the distribution process. In fact, Zipkin's (2001) conceptualisation of mass customisation implied the same thing as the basic model by Lampel and Mintzberg (1996).

In 1997, Gilmore and Pine identified four distinct approaches to customisation, which were collaborative, adaptive, cosmetic, and transparent. They advocated that when designing or redesigning a product, process, or business unit, managers should choose an approach or a mix of some or all of the four approaches to serve their own particular set of customers.

- **Collaborative customisation** - this approach follows three steps: first to conduct a dialogue with individual customers to help them articulate their needs; second, to identify the precise offering that fulfils those needs; and third, to make customised products for them. Collaborative customisation is most appropriate for businesses whose customers cannot easily articulate what they want and grow frustrated when forced to select from a plethora of options.
• **Adaptive customisation** - adaptive customisers offer one standard, but customisable, product that is designed so that users can alter it themselves. This approach is appropriate for businesses whose customers want the product to perform in different ways on different occasions, and available technology makes it possible for them to customise the product easily on their own.

• **Cosmetic customisation** - this approach is appropriate when customers use a product the same way and differ only in how they want it to be presented. In other words, the standard offering is packaged specially for each customer.

• **Transparent customisation** - this approach is appropriate when customers' needs are predictable or can easily be deduced, and especially when customers do not want to state their needs repeatedly. Offerings are customised within a standard package for individual customers.

(Gilmore and Pine, 1997)

To sum up, collaborative customisation changes the product itself in addition to changing some aspect of the presentation and this falls into the design level of the four generic levels. As for cosmetic customisation, it changes only the presentation of the product which happens at the distribution stage. A transparent customisation uses a standard representation to mask the customisation of the product. This process can be classified under either the design or assembly level. Finally adaptive customisation changes neither the product nor the representation of the product but it provides the customer with the ability to change both the product's function and/or its presentation to meet their needs. The continuous developments on the conceptualisation of mass customisation along with the basic model by Lampel and Mintzberg (1996) were summarised by Da Silveria et al. (2001) which is shown in Table 3.3 to which Zipkin (2001) and Alford et al. (2000) have been added.
Table 3.3 Conceptualisations of mass customisation (MC) by different authors

<table>
<thead>
<tr>
<th>MC generic levels</th>
<th>MC approaches</th>
<th>MC strategies</th>
<th>Stages of MC</th>
<th>Types of customisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Design</td>
<td>Collaborative, transparent</td>
<td>Elicitation</td>
<td>Pure customisation</td>
<td></td>
</tr>
<tr>
<td>7. Fabrication</td>
<td>Process flexibility</td>
<td>Tailored flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Assembly</td>
<td>Process flexibility</td>
<td>Customised standardisation</td>
<td>Modular production</td>
<td>Assembling standard components into unique configuration</td>
</tr>
<tr>
<td>5. Additional custom work</td>
<td></td>
<td></td>
<td>Point of delivery customisation</td>
<td>Perform additional custom work</td>
</tr>
<tr>
<td>4. Additional services</td>
<td></td>
<td></td>
<td>Customised services; providing quick response</td>
<td>Providing additional services</td>
</tr>
<tr>
<td>3. Package and distribution</td>
<td>Cosmetic Logistics</td>
<td>Segmented standardisation</td>
<td>Customising packaging</td>
<td>Form customisation</td>
</tr>
<tr>
<td>2. Usage</td>
<td>Adaptive</td>
<td></td>
<td>Embedded customisation</td>
<td></td>
</tr>
<tr>
<td>1. Standardisation</td>
<td></td>
<td>Pure standardisation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Adapted from Da Silveria et al. 2001:3)

The rationale behind combining the different frameworks in Table 3.3 was to better understand the similarities and differences between some of the most referenced customisation frameworks in the literature. In addition, similarities are observed which suggest that many of these categorisations are simply alternative names for similar
Chapter 3 Mass Customisation

concepts. Specifically, the 'fabrication', 'assembly' and 'additional custom work' processes in an MC environment are closely related to concepts of JIT, lean production and flexibility; which are all strategies to remove waste and achieve a flexible manufacturing system.

3.8 Modularity

In the previous section, one of the identified characteristics of mass customisation was modular parts. Modularity is one of the key elements to the success of mass customisation. Another important feature of mass customisation is the possible types of customisation. The following sections explain the two key elements of mass customisation.

3.8.1 Concept of modularity

In the modern global market, customers need variety of individual products and want it be manufactured in a short development time. Manufacturers encounter a problem that they would enforce competitiveness by increasing complexity of products in this global market, at the same time they desire the investment of new equipment and machines can be controlled to a reasonable degree. Modularity of products or manufacture processes is the better solution to solve this problem. 'Modularisation of components to customise end products and services' is one of the five basic approaches to mass customisation proposed by Pine (1993:196) in his book "Mass Customisation: the new frontier in business competition". This concept implies assembling of different component part of products or combination of varied detail of service. One product must be composed by several sub-assemblies; each part can be divided and manufactured separately. Changing in these dynamic manufacturing flows, one can get a variety of products to satisfy customers’ individual needs.
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Hudson (1997:82) explained modularisation as a process by which ‘a product’s components are broken down into modules, each mass-produced at low cost, which are then assembled efficiently in a variety of configurations to meet individual needs’. Modularity-based manufacturing practices have been adopted to achieve the concept of mass customisation and deal with demands for increasingly customised products. In short, modularity is the application of unit standardisation and substitution principle to product and process design to create modular components and processes that can be configured into a wide range of end products to meet specific customer needs.

3.8.2 Product and process modularity

Swaminathan (2001) divided the modularity into product and process parts while discussing the effectiveness of a standardisation strategy in practising mass customisation. In his definition, a modular product is the combination of different components or subassemblies to manufacture one product that suits customer’s individual options. A modular process is semi-finished products that undergo a discrete set of operations and then assembly by distinct manufacturers. Through the comparison of modular and non-modular product and process, the standardisation can be divided into four categories to enable mass customisation. There are four types of strategies for standardisation (Figure 3.1) namely, part standardisation, product standardisation, process standardisation and procurement standardisation.
### Figure 3.2 Operational strategies for standardisation

<table>
<thead>
<tr>
<th>Modular Product</th>
<th>Non-modular Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Standardisation</td>
<td>Carry a limited number of products in inventory</td>
</tr>
<tr>
<td>Maximise component commonality across products</td>
<td></td>
</tr>
<tr>
<td>Process Standardisation</td>
<td>Procurement Standardisation</td>
</tr>
<tr>
<td>Delay customisation as late as possible</td>
<td>Leverage equipment and part commonality across products</td>
</tr>
</tbody>
</table>

(Swaminathan, 2001: 132)

- If the product structure can be modular but the manufacturing process can not, then the part standardisation will be the most effective approach.
- If neither the product nor the process is modular then product standardisation could be the effective strategy for a firm.
- If both the product and the process are modular then the firm can take process standardisation to maximise its performance.
- While the process can be modular but the product cannot, then the firm should take procurement standardisation.

### 3.8.3 Six forms of modularity

Modularisation is breaking down the processes of products or services into its component parts. Brotherton (1997) and Jones (2002) applied modularisation strategies
to hospitality products and the airline catering industry, respectively. There are six forms of modularity that are summarised below:

1. **Component-sharing modularity** - this refers to same component being used in multiple products. For example, in a fast food restaurant, the burger which is a common component is used in a number of menu items.

2. **Component-swapping modularity** - in this case the same product has different components in order to produce a wide variety. This is essentially what the watch company - Swatch does. It is also what pizza restaurants are doing to produce a wide range of different pizzas from a relatively small number of basic ingredients.

3. **Cut-to-fit modularity** - this idea takes basic components and adopts them to meet the needs of individual customers. For instance, the National Bicycle Industrial Company can manufacture 11 million bicycles out of 18 basic models.

4. **Mix modularity** - this approach is based on the idea of a recipe, so that components become something different when mixed together. This has been applied to paints, fertilisers, restaurant menu items, breakfast cereals, and many other processes in which ingredients are mixed.

5. **Bus modularity** - this is based on the concept of a standard structure to which different items can be added. The obvious example is the light track where different lights can be fitted.

6. **Sectional modularity** - this refers to making components in such a way that they can fit together in all sorts of different procedures. The classic example of this is ‘Lego’ toys. Aircraft manufacturers, airlines and caterers are increasingly researching for ways in which aircraft galleys and the equipment can be modularised in this way.

(Pine, 1993)
3.8.4 Benefits of modularity

In the previous section, the six forms of modularity were explained. However, the advantages of modularity have not been discussed. These expected benefits of modularity are as follows:

- Reduced uptime - products are assembled from modular components that can reduce the manufacture time compared to products that are assembled from production line. Essentially, it is a lean approach to eliminate waste (see in section 2.7.4 of Chapter 2).

- Less working capital costs - manufacturing machines and equipment can be reused and perform their effectiveness to reduce per unit cost. The reduction of inventory also benefits logistics management and lowers the cost as it often links to JIT which is designed to lower inventory, raise quality and ensure the deliver of components from supplier to assembler only as require (Rutherford and Gertler, 2002).

- Increased product quality - every modular component can be examined strictly prior to assembly. Each defect parts can be substituted quickly by other similar component.

- Faster delivery - each part of the product can be manufactured at the same time then to assemble the whole product. The standardised process can shorten the waiting time and the product can be delivered faster.

- Better information links between development and production teams - this allows simultaneous product and process development. Designers can adjust their product anytime by changing components during the manufacturing process.

- Increase product variety and strategic flexibility - different components can add up to a variety of products. The market is changing everyday and so are
customer's demands. Various products with flexible strategy can suit the changing market well.

- Economies of scale and scope (lower cost) - the standard manufacturing processes have the benefits of economies of scale. The flexible product and process belonged to economies of scope.
- The ease of product upgrade, maintenance, repair and disposal, and faster product evolution - the renew steps of products are quick and can keep up with a changing market. The immediate information communication between design and development, manufacture, and delivery can induce the adjustment of product to fit customers' preferences.

3.9 Process model in a mass customisation system

So far, the conceptualisations of mass customisation were broadly investigated in all the literatures reviewed. However, MacCarthy et al. (2003) observed that existing literatures failed to provide sufficient information for the formulation of a process oriented model in a mass customisation environment. In addition, MacCarthy et al. (2003) mentioned that the main characteristics of mass customisation have yet to be fully understood. This section examines the development of a complete process model by MacCarthy et al. (2003) that is not constrained by the dominant use of a value chain perspective, unlike previous models by Lampel and Mintzberg (1996); Alford et al. (2000), Pine and Gilmore (1997) that were based on the value chain as shown in Table 3.3 in the previous section. Figure 3.2 depicts the operations processes in a typical mass customisation system.
Figure 3.3 Operations processes in a mass customisation system

(MacCarthy et al., 2003:296)

- Order taking and co-ordination - involves communication with customers so as to recognise any special needs or requests for a product by customers.
- Product development and design - accommodate the external and internal criterion of a product design established by the customer.
- Product validation and manufacturing engineering - this process confirms the practicability in fabricating a particular product design. It involves the assembly of resources required for the production of the customised product and draws on a set of manufacturing/service guidelines for routing and processing purposes.
- Order fulfilment management - this process serves as a value adding component. It is linked to “order taking and co-ordination”, hence enabling customers to find out the progress of their requests. In addition, this process manages the overall order completion activities.
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- Order fulfilment realisation - comprises all events in the process of making the customised product, including supplier activities, internal production procedures and distribution.

- Post-order process - relates to the availability of services following the completion of an order. For examples, warranty, claims and feedback forms.

(MacCarthy et al. 2003)

In order to identify the scope of mass customisation (MC) and the range of operations that qualify as mass customisation, MacCarthy et al. (2003) analysed the six relevant classification schemes of mass customisation - Lampel and Mintzberg 1996; Ross 1996; Alford et al. 2000; Duray et al. 2000; Da Silveira et al. 2001; Gilmore and Pine 1997 - and applied them to five case studies - National Bicycle Industrial Company, Motorola bandit pagers, European bicycle manufacturer, Computer assembler and Commercial vehicle manufacturer - to consider their suitability and potential for developing configuration models. However, the authors found that these classification schemes do not distinguish and differentiate key characteristics of mass customisation.

MacCarthy et al (2003) identified these important distinguishing factors and used them in the identification and development of the fundamental primary operations mode for mass customisation. The model has six processes that are fundamental to mass customisation: order taking and co-ordination, product development and design, product validation and manufacturing engineering, order fulfilment management, order fulfilment realisation and post-order process. Linking the permutations of the distinguishing factors leads to establishment of fundamental operational models for mass customisation (MC). Five fundamental modes of operation—mode A: catalogue MC, mode B: fixed resource design-per-order MC, mode C: flexible resource
design-per-order MC, mode D: fixed resource call-off MC, mode E: flexible resource call-off MC - are identified and justified. They are distinguished on if the products design and validation/manufacturing engineering is by per order or by per product, the order is by once off or by call-off, the order fulfilment activity is fixed or modifiable. Figure 3.3 illustrates the five fundamental modes of operation.

Figure 3.4 Five fundamental modes of mass customisation

(MacCarthy et al., 2003:298)

These modes can help to understand why enterprises evolve into one mode rather than another and how the infrastructure and processes within an enterprise must change if there is a move between modes. The five different modes are described below:
Mode A - "Catalogue mass customisation", a customer request is fulfilled from a pre-designed catalogue of selections produced using standard order fulfilment procedures. In this mode, the engineering of products is not correlated to requests but are completed even before requests are taken. Customers select from a pre-specified choice and products are assembled by order completion activities that are already in place. Similarly, the order fulfilment activities are engineered prior to an order being received.

Mode B - "Fixed resource design-per-order", in this case, a customer request is satisfied by producing a customer specific product, created through standard order fulfilment processes. The customer places an order for the product but no repeat orders are anticipated. In this mode, there is some degree of product engineering for both the customer and the manufacturer/service provider, unless a customer’s needs happen to match a previous order, in which case the product design is recycled. Given that the order completion procedure is standard; all designs have to be appropriate for the process. For this reason, it is important that the product development process recognises its process capabilities.

Mode C - "Flexible resource design-per-order", here, a customer request is also completed by manufacturing a customer specific product, but produced through modified order fulfilment procedures, where a new supplier or subcontractor is engaged to facilitate the production of the customised product. The customer requests for a product and there is no expectation of repeat orders. In this mode, products are produced per order and the order fulfilment process may be personalised per order.

Mode D - "Fixed resource call-off mass customisation", a tailored product is designed
for a customer, to be made via standard order fulfilment processes in expectancy of repeat orders. At the prompting of a customer, a product is designed and manufactured through the standard order fulfilment process, whereby customers' choice is limited by the capabilities of manufacturer's/service provider's existing order fulfilment resources. Here, the customer can order the same item again, any time in the future.

Mode E - “Flexible resource call-off mass customisation”, this mode is similar to Mode D except for the fact that order completion activities are modifiable. A customer request is met by engineering a customer specific product, which is produced through made to order fulfilment processes, whereby a manufacturer/service provider is prepared to vary its order fulfilment resources by outsourcing to new suppliers. In this case, there is the possibility of repeat orders.

3.10 Technological enabler for mass customisation

In this section, a technological enabler (computer technology) for realising mass customisation is discussed. The most obvious enabler of mass customisation is technology. Computer technology is thought of as the central enabler (Sahin 2000) and remarked that mass customisation owed its success partially to computer technology and the collapse of traditional information costs. In 1998, Crainer stated that the advancement in technology led to the ease of capturing and utilising information about customer needs and behaviours. In addition, he mentioned new technologies which provided new ways to manage the physical flow of goods. The internet is already enabling manufacturing, and is one of the principal enablers for mass customisation. Some of the opportunities offered by the internet are as follows (Crainer 1998):

- With Internet, companies are able to exchange information and transactions more easily with customers, suppliers and distributors.
• Companies are able to bypass others in the value chain. For example, a book publisher could use the internet to bypass book retailers by selling directly to customers.

• The ability to develop and deliver new products and services for new customers are possible with the Internet.

3.11 Conclusion

In the previous chapter, the two predominant types of operations in any production firms (job shop and mass production) were discussed. Over the years, consumers have become more demanding not just on the price of products but also on the variety they can choose from. Job shop or mass production can no longer cope with the demand and ever changing market. A new operation strategy known as mass customisation can address the problem of achieving simultaneously both high volume and variety in a production firm. The general definition of mass customisation is to provide customised product/service at the lowest possible cost. In order to clarify the concept of mass customisation so as to have a better understanding of how mass customisation enhances efficiency, an understanding of the characteristics of mass customisation that differs from job shop or mass production based on the basic model of four generic levels first introduced by Lampel and Mintzberg (1996) is necessary. The comparison between the three processes is shown in Table 3.2 which shows that parts of a mass customisation product can be modularised. Moreover, the operation layout is modular meaning that common equipment, resources and processes to facilitate the production of modular parts of designs are grouped together.

Other conceptualisations of MC built upon the basic model by other authors were discussed. In general, their strategies and approaches to achieve MC, more or the less
suggested the similar concepts, albeit different naming conventions. MacCarthy et al. (2003) came out with a process-oriented model of a mass customisation system that is a more practical framework. In this chapter, modularity and types of customisation are two important factors to the successful implementation of mass customisation. In addition, a technological enabler (computer technology) is essential for establishing a link between suppliers, customers and manufacturers in order to understand their requirements and realise MC more effectively.
Chapter 4 Flight Catering

4.1 Introduction
The importance of the flight catering industry is not to be underestimated because it is probably one of the most complex operational systems in the world (Jones, 2004). Flight catering now is a global industry with an annual turnover in excess of US$14 billion where approximately 30% is generated in Europe, 35% in the Asia/Pacific region and 26% in North America (ITCA, 2005). Such great value of production should progress under a well-organized operations strategy or management. This chapter describes the relationship between airline companies, passengers, caterers and distributors to determine what roles they play in the flight catering industry. A focal point of discussion is the current operation processes in the flight catering industry. From the operation processes, the characteristics in this industry can be identified. The future trend of the flight catering industry is also concluded in this chapter.

4.2 The growth of flight catering industry
In 1919, flight catering began with passenger services for the regular airline between England and France (Jones, 2004). With the new aircraft developed, the type of service has improved from simple sandwiches to sophisticated food service. International scheduled passenger journeys currently exceed 550 millions per annum and domestic scheduled numbers are over 1,260 millions annually (ITCA, 2005). In addition, the flight catering may be one of the most complex operational systems in the world. Approximately 600 flight kitchens existed worldwide. The average kitchen prepares between 6,000 and 7000 meals every day, and employs around 150 people. There are a number of larger kitchens, employing over 1,000 people and over 9 million meals per year (ITCA, 2005).
LSG Sky Chefs and Gate Gourmet, now the two largest global catering players' service just over half the worldwide market. Regional and niche caterers account for about another 25%, with the remainder being handled by small local companies. The latter two caterer groups include many airlines especially in the Asia/Pacific region, which still have their own flight kitchens. They handle third party carriers as well as their own company needs. Supplier companies vary widely by type, with some big niche players dedicated to the industry while others are specialist aviation divisions of larger organisations (ITCA, 2005). The modern consumer is generally well informed and has high expectations of value for money. The passengers will judge the airline service by meals arriving to his/her seat at "the right time, the right quality and price". Therefore, with the growth of air travel, many old systems and infrastructures are required to update and firms need to develop new operational strategies.

4.3 Current scene of the airline industry

The in-flight catering business is facing tremendous challenges at present. Several of their main customers have been in severe financial difficulties in the past couple of years, putting severe pressure on their suppliers. In an effort to save costs, many airlines have opted to scrap free meal offerings for economy class passengers on short-haul flights and are switching towards to offering them on a pay-as-you-go basis. Consequently, the whole of the airline supply chain as well as carriers have strived to cut their costs in order to face the global challenges since the airlines have continued to tighten their belts post 11 September 2001, SARS and Tsunami Earthquake.

According to industry estimates, the in-flight catering market has shrunk in size by about 30% in the past four years (2001-2004). Especially, the US market has been most affected with volumes down about 40%; therefore, the revenues of in-flight catering
companies have fallen. For example, Gate Gourmet has fallen 35% and has not actually made a profit since 2000 (BBC, 2005). The soaring oil prices have made this already-difficult situation worse. The airlines' fuel costs have risen by 20% and produced a fierce competition among suppliers. With increasing oil prices, this situation will continue to degenerate.

Decreases in work opportunities forces the companies to reconstruct their organisation, adjust working practices, cut down pay, and even reduce their workforce. During August, 2005, Gate Gourmet, one of the world's largest providers of in-flight meals, operating in 29 countries and employing 22,000 people, making 534,000 meals per day (BBC, 2005), laid off 670 staff and encountered a wildcat unofficial strike by the caterer's staff. Gate Gourmet aims to reduce its workforce in order to make the company economically viable. One day later British Airways' ground staff at Heathrow walked out in sympathy, forcing the airline to shut down operations at the airport - resulting in the loss of £30m as it cancelled 700 flights. The British-based workers have been replaced by low-paid workers in various far-flung parts of the world. But where British Airways has got things horribly wrong is by thinking that in outsourcing its in-flight food catering, it could rely on a single supplier - indeed, the very same operation that it outsourced eight years ago.” Downes (2005) pointed out that this is the peril of outsourcing.

Gate Gourmet lost £25 million in 2004, and in 2005, its losses were estimated to be as high as £1 million per day. LSG Sky Chefs, the rival of Gate Gourmet, is the world's largest provider of integrated in-flight catering, procurement, equipment, retail and in-flight management. LSG Sky Chefs caters 270 airlines from more than 200 customer service centers in 48 countries and produces around 362 million airline meals a year. In
2004, the companies belonging to LSG Sky Chefs Group achieved consolidated revenues of €2.3 billion (LSG, 2005). However, it also has cut 12,000 jobs over the past four years, reducing its workforce from 41,000 to fewer than 30,000 (BBC, 2005). The challenges and problems faced in the airline business have called for alternative measures and strategies to bring this business back to life. This study was structured to investigate the effect of MC, which may lead to improvements in the operational efficiency “betterment” of the flight catering industry.

4.4 Relationship between major parties in the supply chain of flight industry

'Along with passengers and airlines, suppliers to the industry were needed from the very earliest days and dedicated flight catering companies were founded in the 1940s and 1950s. In some cases, airlines formed their own flight catering divisions, in other cases, these were independent of any airline' (Jones, 2004:16). Due to the nature of the business, airlines, caterer suppliers, manufacturers, and handling agents are the major parties involved in the supply chain. The relationship of their roles in the flight catering is showed in Figure 4.

Figure 4.1 The relationships of major components for flight catering

(Jones 2004:16)
Airlines concentrate on determining their customers' needs and defining the specification of the flight service. Some airline companies operate their own catering companies. Since airlines are responsible for the complex design of onboard service, the nature of onboard service varies widely from flight to flight and airline to airline. Caterers have two main roles, to prepare those items not bought in directly from suppliers and to assemble trays and trolleys (Tabachi and Marchall, 1988). Caterers must work very closely with many airline personnel in order to satisfactorily serve their customers - the airlines.

There are two main types of manufacturer. One supplies airlines (or their caterers) with their standard products and manufacture of these products takes place in a factory or plant where they produce many other products for many different markets. The other manufacturer, supplies special products specifically designed for the flight market. Because of the cost of space and the cost of labour, the manufacturer may have a plant specifically located near to the major airport. The handling agents (distributors) are relatively new in the relationship between the airline and the caterer. They must distribute goods from thousands of suppliers to the flight kitchens under the direction of the airline and the caterer. They should also provide a tracking system that can control the product flow. Another benefit of working with a distributor is that they can either find a product or find a company to design products that the airlines or caterers want. However, the airlines maintain strong control over caterers and suppliers as well as having interaction with passengers.

4.5 Flight catering operation processes

This section focuses on that stage in the flight catering process termed 'In flight Kitchen'. A number of key sub-processes take place as follows:
• The preparation of cold food items.
• The production and then chilling of hot food items.
• The “dishing” of food items (placing each food item in the appropriate container, such as badge crockery, aluminium foil container, and so on).
• Tray assembly - laying up trays with all necessary items (except hot food which is placed in oven boxes)
• Bar and equipment trolley lay-up - loading all other types of trolley that store items on board
• Trolley assembly - putting together all the necessary trolleys for a specific flight

Nevertheless, the complexities of operational processes in the flight catering industry need to be assist with IT system for daily operations. Figure 4.2 illustrates the process and information flow for the flight catering system.
In this context, the flight kitchen exhibited many of the characteristics of batch operations, as illustrated in Figure 3.4 of Chapter 3. If each of the processes within the flight kitchen were analysed in relation to Figure 4.2, it would indicate different stages typically adopt different approaches:
Chapter 4 Flight Catering

The preparation of cold food items - much of this can be done irrespective of which flight the raw materials are for. Salads can be washed and prepared, vegetables cleaned and peeled, and so on and put into inventory, only being taken out of inventory when needed for specific flights.

The production and chilling of hot food items - this is very much a job shop operation. The number of hot meals prepared, especially for first and business class, is relatively low.

Dishing of food items - the ‘dishing’ of food items is done on a batch basis. Figures 4.3 and 4.4 depict the dishing of food items on a conveyor belt and tabletop respectively.

Tray assembly - there are three major types of assembly for preparing trays in flight catering - table top, conveyor belt and cellular. While preparing meals for First Class, it needs trained staff needs to assemble at the stationary work surface (see Figure 4.4). This can be either at a table or in the cellular assembly area that is more popular these days. In this area, all items from food to equipment and condiment are available on a two-tiered shelf and table system. The operative (general catering assistant) will finish the complete meal and load directly into the airline meal cart. Volume meals or less complex meals such as Economy Class standard may be produced using the conveyor belt.

The section assistants handle each part of the items and the belt continues to transport the tray forward and each food item is added separately through the flow. Assistants assemble the meal in accordance with the recipe of chefs who creates the meal and verify through photographs. Each container has different colours or shapes in order to be easily identified by the staff. Business/Club Class is usually a mixture of tray set and loaded items, but they are served individually to the passengers. Economy Class will be a total tray set with just the hot component and will be served separately.
Bar and equipment trolley set-up - most flight kitchens try to use assembly line or mass production principles for bar trolley assembly. Indeed, Finn Air in Helsinki has an automated facility that only requires five staff to process all their needs based on the computer controlled movements of inventory and finished stock.

Trolley assembly - trolley assembly is also based on each flight. All flight requirements for examples, drinks, tableware linen, toiletries, newspapers and magazines are packed into appropriate trolleys and containers for aircraft type. Every type of trolley has a layout diagram in order to identify which items should be loaded onto the trolley.
Batch assembly and line assembly are two methods of dish packing and tray assembly. In batch assembly, a single worker at a workstation assembles everything onto trays and puts these into a trolley. In line assembly, the tray moves along a conveyor belt and different workers put on different items until the completed tray reaches the end of the line.

Two other methods are also used in tray assembly recently. Kanbans, originated in Japan means 'card', refers to a container in which parts or components are moved from one work area to another. Each Kanban is large enough to hold a small and fixed number of identical items. The employment of Kanban is touching the heart of the just-in-time (JIT) approach. In addition, 'Poka-Yokes', which is Japanese for a fail-safe device can be incorporated into machinery to ensure their proper use (Jones, 2004).

The above mentioned operational processes of the flight catering industry show a mixture of job shop, batch processes and mass production being implemented. Evidently, this industry exhibited characteristics which make mass customisation a logical development because of the hybrid nature of mass customisation. Mass customisation is designed to integrate job shop, batch process and mass production into a single system.

4.6 Potential for adopting mass customisation in the flight catering industry
A number of carriers are experimenting with ways in which all their customers' experiences can more closely match their individual needs. Some carriers provide a wider range of menu items for passengers who wish to pre-book their meals. For instance, Air India makes it possible to order via the Internet up to 48 hours before flight
departure. Passengers on charter flights can order their meals when they make their reservations. Another alternative is to allow passengers to eat when they want by selecting from the buffet menu, such as British Airways' Raid the Larder concept. Short haul flight passengers can have their desired food or beverage at the airport instead of onboard. The following section signifies the possibility of mass customisation has been adopted in the flight catering industry.

4.6.1 Volume and variety characteristics of the flight catering industry

A single flight by a long-haul Boeing 747 (the “jumbo jet”) may require over 40,000 separate items loaded onto it (Jones 2004). Flight kitchens at major hubs, such as London Heathrow, Frankfurt and Atlanta may be handling twenty or more 747s, as well as many smaller flights per day. Hence it is very clear that flight kitchens handle a considerable volume of products on a daily basis. In essence, airlines require caterers to provide all meals, beverages, and perhaps other products such as paper goods, blankets, magazines, headsets, amenity kits and so on. In the course of a year this involves handling millions of corrugated salt and peppers, sugar packets, napkins, mustards, mayonnaises, salad dressings, dishes, snacks, soft drinks, coffees and so on. Items for consumption during the meal include breads, rolls, meats, vegetables, and desserts, greens for salads, cheeses, fruit drinks, wines and spirits (Tabachi and Marshall 1988).

Moreover, most airlines cater to the specific dietary needs of their passengers that result from religious persuasion or medical conditions. There are therefore 26 different types of ‘special meal’ that may be provided, such as kosher, halal, low fat, low salt and vegetarian. In addition, crew meals are often designed to be different from passenger meals, since the crew are engaged in active work and require higher energy intake. By law, the pilot and co-pilot are required to eat different meals, so that should one become
ill from food poisoning the other would be unaffected. Therefore, even within one airline there may be a wide variety of menus and meals.

Most flight kitchens contract to supply more than just one airline, as there are few airports where a single airline has enough flights to justify the exclusive use of a kitchen except for the 'hub' airports of major carriers. Hence, within flight catering there is a considerable variety of outputs. In each flight kitchen, this variety is derived from:

- Number of airlines
- Types of airline - scheduled, charter, low-cost, executive
- Duration of flight - short haul, long haul
- Seat class - first, business, economy
- Day part - breakfast, mid-morning, lunch, mid-afternoon, dinner

Evidently, flight caterers not only have to deal with the large volume of products to provide, but also the high variety issue.

4.7 Trends in flight catering

4.7.1 Airline mergers and catering outsourcing

Since the short haul market is very competitive, small caterers face fierce competition from big player like LSG/Sky Chefs. The only way to stay in business is to merge with other small caterers. However, merging is just a means of survival not competition. In Middle East and Far East areas, the only big players are caterers that have government investment and support. Examples include Singapore Airline and Air China. In the United States (US), there are four or five big carriers, but in Europe each country has their own national carrier. Thus, this is a very fragmented industry. Competition rules within European Union makes it difficult to be subsidised by the government. Merging
of airlines and concentration of caterers will be the future trend. For example, LSG/Sky Chefs have about 200 kitchens among 600 kitchens in the world. This means LSG/Sky Chefs owns about 30% of the market which means one third of meals onboard are served by LSG/Sky Chefs.

In the US there are many domestic flights and their market structures are clear. They have contracted the in-flight meal with outsourcing caterers since 1947. However, it is a different pattern in Europe. The flights are mixed by long haul and short haul (meaning within Europe). In the past, most national carriers operate their own catering service but now they are outsourced just like the US. In Middle East and Far East, since they have a lot of long haul flights, traditional market has their own catering instead of outsourcing. They will become more like Europe in the future.

Larger firms might be able to achieve economies of scale, which helps to drive costs down. However, smaller and local operators will find it difficult to compete in this market under these conditions. Eventually, global catering firms may take over the market to provide sole sourcing to global airlines throughout the world. A recent contract between Gate Gourmet and Delta Airlines, the world’s top airline in year 2001 with passenger numbers over 105 million, suggested that such strategic alliances might become more common in the future.

4.7.2 Information technology

The environment of in-flight catering is not stable and permanent. New design and technique are developing to solve problems encountered in product processes. In order to improve productivity rate and efficiency, many modern designs and techniques are applied to the assembly, storage and transport of in-flight catering materials. For
example, Gate Gourmet facility in Zurich has adopted bar coding and used a scanner to read transported production. Besides, some companies and equipment manufacturers tend to introduce automating processes to substitute for intensive manpower in tray assembly operations. Furthermore, a simple and manageable automated system can monitor food temperature, refrigeration temperature and the cooling system temperature. More than that, there is an alarm warning to avoid false information.

Internet-based platforms promise the opportunity for many people, such as suppliers, caterers, airlines and even customers. The purpose of web-based platforms is to share the same information in real time at different locations. The growth of large global catering firms enables the required investment to develop such capability. The platform tracks personal taste and sends email to the customers. Handheld computers (PDA) can help to eliminate some paper work and allows crew to send email on board. E-commerce clearly has a role in managing logistical challenge.

The arrival of “eLSG/Sky chefs” and “Egatematrix” in 2001 assisted the world’s two largest flight caterers (LSG/Sky Chefs and Gate Gourmet) in managing equipment, procurement of raw materials and basic information dissemination (Lundstrom, 2001). For instance, Gate Gourmet’s Internet-based e-business solution (“Egatematrix”) offers a web-based ordering system that allows passengers to order their meals (Gate Gourmet, 2004). Mobile phones can access an on-line menu for passengers to select meals. Gate Gourmet has several innovative and creative approaches for flight catering, such as Global Service Excellence and “Egatematrix”, an in-flight food for sale program, on-line pre-order meal system, and strategic alliances with other businesses. These practices do not show how Gate Gourmet fully practices mass customisation for their
process planning and operations management yet. However, it is the first step that caterers use for mass customisation into its operations management.

4.7.3 Shift in Value chain

A future trend will observe the elimination of processes that do not add value to the chain. Everything we buy/service goes through a series of stages. Suppliers provide the food, caterers add value by cooking the food, and caterers add value by transporting the trolley to the aircraft. If they do not add value, they must be taken out of the process. How to shift/add the value chain? One of the ways is outsourcing. More and more airlines and caterers are outsourcing their products from famous brand manufacturing in order to reduce labour costs and to provide a variety of products. Diverse offerings range from McDonald's Friendly Skies Meals (usually a chicken or salami sandwich, cheeseburger, fruit or vegetable, dessert, milk carton and toy) to the Japanese bento box or a vegan meal. The second way is to reduce packaging; overlapping package is just producing more waste on board. For cost and environmental reasons, caterers should avoid excess packaging on meals.

The third way is to locate the closest airport. Flight kitchens by their very nature need to be located very close to the airport and they must be very large to process high-volume orders and to store all the equipment and stock. Many flight kitchens are literally located on the airport’s perimeter, so that goods inward arrive land-side, but the high-lift trucks that deliver to the aircraft can depart from an air-side loading bay. Often, turn-round times are short only 90 minutes is allowed to off load and re-supply a 747 aircraft. The fourth way is to process re-engineering automation. But tray assembly remains a labour-intensive activity with some debate whether production line flow method whereby several workers fill-tray type or individual workstation is the best approach.
Chapter 4 Flight Catering

The former is probably the ideal for high volume but low variety meal when dealing with many long-haul flights for a single airline. On the other hand, the latter probably would be the most effective approach in dealing with small contracts for many short-haul flights.

New approaches of production management and quality management, outsourcing of materials and JIT inventory not only can reduce the number of activities taking place at the operation, but also can control and reduce the level of stacking and waste materials. Gate Gourmet and LSG Sky Chefs have been engaged in process re-engineering, which refers to looking at all the processes within the unit and looking at ways in which the process can be made more efficient and effective, increasing both of productivity and quality. It also removes of all kinds of ‘waste’, such as waste time, waste movement, waste stocks, which resulted from the process (Jones, 2004).

It concludes that in-flight catering has adopted JIT, lean production already. The catering industries should take process re-engineering on planning and reorganise their operations to catch the changing over time.

4.8 Conclusion

Flight catering may be the most complex operational systems in the world. This industry not only has to provide bulk volume of products on a daily basis, that include snacks, confectionary, breads, appetizers, meats, vegetables, desserts, salads, cheeses, soft drinks, beers, wines and spirits; but also has to serve different airlines at the same time. Besides, flight caterers have to cope with the different classes, types of airlines (charter, schedule, low cost), day parts (morning, mid-morning, lunch, mid-afternoon, dinner) and so on. Hence, the flight catering business is clearly characterised by high volume
and high variety. As discussed in this chapter, the flight kitchens adopt job shop and batch process evidenced by conveyor belts and workstations. In addition, large caterers use agility, lean production and JIT methods to cope with high volume and high variety issues.

Since mass customisation is a hybrid of mass production and job shop, and the fact that there is no trade-off requirement between achieving high volume and high variety as illustrated in the adapted Hayes and Wheelwright's (1979) trade-offs diagram in the previous chapter; the flight catering industry lend themselves potentially to mass customisation. In this way, the problem of having to cope with high volume and variety simultaneously is alleviated.

The challenge of airline flight catering development in the future tends towards mass customisation, a trend that has already been adopted in the manufacturing industry. Each passenger's unique flying experience needs to be taken into consideration to customise their needs and tastes. Market demand plus new technologies may allow airlines to provide all customers with pre-ordered customised meals in the future. Mass customisation can make a good profit on the flight catering industry if it can be practiced more properly. When mass customisation concept and method are implemented in the flight catering industry, many issues may need to be reconsidered. It still needs further research and analysis on how to use the existing MC strategies discussed in chapters 2 and 3 more effectively and efficiently that make the production process smoother in order to meet the demands of high volume and high variety in the flight catering business.
Chapter 5 Research Methodology and Design

5.1 Introduction
This chapter describes and explicates the research methodology and design presented in the study. Both quantitative and qualitative methodologies are reviewed, highlighting the respective advantages and disadvantages over each stance. In consideration of the merits of both methodologies, the research design for this study seeks to utilise both quantitative and qualitative approaches in order to leverage the advantages of them. The quantitative approach undertaken is by Data Envelopment Analysis (DEA) to identify efficient and inefficient flight catering units. Further, qualitative case studies on the efficient and inefficient units are carried out by protocol interviews to determine and understand important factors (inputs and outputs) in the operational process that have significant contribution to the performance of the flight catering industry.

5.2 Purpose of the study
From the literature review there is a prima facie case that the flight catering industry has been adopting a number of processes and techniques associated with mass customisation. The purpose of this study is to determine if mass customisation has been adopted in the flight catering industry. However, mass customisation is a general concept which may include a number of dimensions such as labour flexibility, JIT, modularity, lean production, and flexible/agile manufacturing strategies. These too will be investigated in order to try to understand their relative contributions to improved efficiency. It is hoped that the study will lead to an understanding of those changes that have lead to ‘improvement’ and those that have shifted the performance frontier, i.e. ‘betterment’.
5.3 Positivism and interpretivism approaches to research

Traditionally, approaches to research of science in general fall into two schools of thoughts: *positivism* and *interpretivism*. These two approaches have different viewpoints on how research is conducted and analysed.

Observations of the phenomena under investigation can be argued objectively and justified rigorously by measurements in the eyes of a positivist. The positivism approach is described by Keat and Urry (1975:25) as "only one logic of science, to which any intellectual activity aspiring to the title of 'science' must conform". Kolakowski (1993:7) gives a general definition of *positivism* as "a collection of prohibitions concerning human knowledge, intended to confine the name ‘knowledge’ or ‘science’ to the results of those operations that are observable in the evolution of the modern science of nature". Neuman (2000:66) further explains "*positivism* sees social science as an organized method for combining deductive logic with precise empirical observations of individual behaviour in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity".

In general, a positivist inquiry into social science problems seeks to discover answers through empirical data collection. Knowledge claims that cannot be justified by empirical data are therefore rejected by *positivist* views.

While *positivism* centres on external, observable phenomena, *interpretivism* on the other hand focuses on the internal, on the motivations and experiences that explain human behaviour. The need for an *interpretivist* methodology is emphasised by Schwandt (1998:222) stating "The quest for the understanding of social processes and actors led to the conviction that in order to arrive at meaning, interpretation must take place." Neuman (2000:71) defines *interpretivism* generally as "the systematic analysis
of socially meaningful action through the direct detailed observation of people in
natural settings in order to arrive at understandings and interpretations of how people
create and maintain their social worlds”. The interpretivism requires more involvement
of the researcher with the subjects of study in order to develop an understanding of
social life and discover and compile meanings by subjects under study in a natural
setting. The interpretivist approach to analysis is largely emphasised on detailed
readings or examinations of texts, conversations, written words or pictures to uncover
meanings embedded within them. A deep understanding of how parts of texts relate to
the whole is then developed.

Neuman (2000) opined that the positivist approach is employed for most quantitative
research to social sciences in terms of emphasising precisely measuring variables and
testing hypotheses linked to general causal explanations. Conversely, qualitative
research relies on interpretivist approach, seeking to understand behaviours and
thinking of individuals or groups and being conducted in an environment that is deemed
natural. The following section describes the differences and criticisms between
quantitative and qualitative research strategies.

5.4 Debate of qualitative and quantitative methodologies
Within the social sciences, there is still the longstanding philosophical debate over any
one best method to research the social world and a consensus has never reached
agreement. In general, this debate focuses on which of the two methodologies –
qualitative or quantitative, is more appropriate for conducting research in the social
world.
Chapter 5 Research Methodology and Design

Qualitative research, in a broad sense means "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Strauss and Corbin, 1990:17). Arksey and Knight (1999) further explain that qualitative research is an approach to understand the thinking and behaviours of individuals and groups in specific situations, and can direct attention phenomena in context-specific settings.

Quantitative methodology on the other hand, “has allowed the logic and procedures of natural science to provide an ‘epistemological yardstick’ against which empirical research in social science must be appraised” (Bryman, 1988:12). The theory of knowledge or epistemology, is about finding better ways to acquire beliefs and criticised the beliefs people already have (Morton, 2003). Therefore, qualitative and quantitative research paradigms are based on very different assumptions about both theories of knowledge (epistemology) and the appropriate means of generating knowledge (methodology). With regard to epistemology the quantitative research assumes the researcher to be independent from that being studied so that the research process approach is an unbiased one. In a broad sense, quantitative research assumes knowledge about the social world can be proved or disproved, leading to the uncovering of laws and generalisations that describe the world and allow good predictions to be made. A different epistemology is assumed in qualitative research where there is interaction between the researcher and that being studied. Qualitative research assumes that knowledge can be held by an individual or individuals, and seeks to uncover an individual’s or individuals’ subjective knowledge about the world.

Another difference between qualitative and quantitative methodologies lies in the nature of data. Quantitative methods result in numeric data that can be analysed by
Chapter 5 Research Methodology and Design

statistical tests and methods. The data obtained by qualitative methods is in the form of
textual or narrative descriptions (Miles and Huberman, 1994). In addition, quantitative
research is inductive whereby a hypothesis is needed before the research begins.
However, qualitative research may be deductive and a hypothesis may not be needed to
begin the research.

There have been criticisms on both quantitative and qualitative methodologies.
Marshall and Rossman (1999) deems qualitative research to be a more flexible
approach than quantitative method in that the objective is to discover unanticipated
findings as opposed to predetermined theories. Denzin and Lincoln (2000) remarked
that a qualitative researcher studies things in a natural setting which is in contrast to
quantitative research that does not take into account the existence of many interaction
effects in social settings. This implies qualitative inquiry is more appropriate for the
study of the complex and dynamic quality in the social world. As mentioned earlier,
quantitative data is characterised by numeric data whereas qualitative data is
predominately texts or words. Therefore, qualitative data can be unstructured and
unbounded because it concerns people's behaviour which is argued by Lee (1991) as a
lack of controllability and deductibility.

Qualitative research is not without its critics, despite being an accepted approach to
social inquiry (Bryman, 1988). A known problem of qualitative research is that of its
sample size. Due to the in-depth nature of qualitative approach, the sample size tends to
be smaller which is considered by some critics to be misleading and therefore
generalisations cannot be made (Mason, 1996). Also, there is the issue of bias which is
often seen by a quantitative researcher to be more acute in the qualitative approach.
Qualitative researchers are often called soft scientists because their works are
unscientific, or only exploratory, or entirely personal and full of bias. Table 5.1 summarises the comparison between quantitative and qualitative research methodologies. In general, the two approaches differ in their philosophical stance which is reflected in the kind of methodology they employ.

Table 5.1 Comparison between quantitative and qualitative methodologies

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Quantitative Approach</th>
<th>Qualitative Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Methods</td>
<td>- Social surveys</td>
<td>- semi and unstructured interviews</td>
</tr>
<tr>
<td></td>
<td>- Self administered questionnaires</td>
<td>- Participant observation</td>
</tr>
<tr>
<td></td>
<td>- Structured interview</td>
<td>- Oral/life histories</td>
</tr>
<tr>
<td></td>
<td>- Structured observations</td>
<td>- Unstructured interviews</td>
</tr>
<tr>
<td></td>
<td>- Content analysis of official statistics</td>
<td>- Content analysis of documents</td>
</tr>
<tr>
<td>Variables and hypothesis</td>
<td>Define the variables before data collection. A hypothesis</td>
<td>Define general concepts where variables are the products of</td>
</tr>
<tr>
<td>requirements</td>
<td>is needed before research begins where the hypothesis is</td>
<td>the research. No hypothesis is needed to begin research.</td>
</tr>
<tr>
<td></td>
<td>then tested on data</td>
<td>Hypothesis may emerge as a result of research</td>
</tr>
<tr>
<td>Data Type and logic of</td>
<td>Uses numbers. Statistical generalisation meaning that</td>
<td>Uses words, textual or narrative nature. Theoretical</td>
</tr>
<tr>
<td>generalisation</td>
<td>hypothesis is tested against data</td>
<td>generalisation meaning data is examined to</td>
</tr>
<tr>
<td></td>
<td>to explain research cases</td>
<td>determine axiom that fits all research cases</td>
</tr>
<tr>
<td>Sample Size</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Analytic Approach</td>
<td>Deductive, technocratic perspective (more with positivism),</td>
<td>Inductive, transcendent perspective (more with interpretive</td>
</tr>
<tr>
<td></td>
<td>reductionist</td>
<td>and critical approaches), holistic</td>
</tr>
<tr>
<td>Source of bias</td>
<td>Biased samples</td>
<td>Selecting data to fit a preconceived idea.</td>
</tr>
</tbody>
</table>

(Source: Bryman, 1988; Brannen, 1992; Blaikie, 2000; Neuman, 2000)
5.5 The value of mixing methods

As pointed out in the previous section, both qualitative and quantitative methodologies have their own drawbacks and strengths. Despite the divergence of qualitative and quantitative methodologies, the two methodologies can be reconciled to advocate the idea of combining the two methods together. The concept of multiple-methods employed in a single study is termed as triangulation. A triangulated approach facilitates the cross checking of results by using different methods. Denzin (1989) defined triangulation as the combination of methodologies to study or research the same phenomenon. Triangulation is regarded as a strategy to overcome problems of validity and bias (Patton, 1990; Mason, 1996; Arksey and Knight, 1999). By combining methods, researchers can hope to overcome the weaknesses or intrinsic biases and the problems that come from a single method (Brannen, 1992). As Denzin (1989) pointed out, interviews can be influenced by a myriad of factors and a multi-method approach goes some way towards achieving validity. In light of this approach, a mixed methodological design based on the triangulation between qualitative and quantitative methods is adopted for this study.

The need for adoption of multiple-methods was stressed by Burgess (1994) who urges researchers to be flexible in their approaches, carefully selecting a range of methods that are appropriate to the research problem under investigation. He believes that field methods which do not encompass observation, informant interviewing and sampling are deemed as narrow and inadequate (Burgess, 1994).

Arksey and Knight (1999) argued that triangulation can strengthen functions of confirmation and completeness bearing on the same phenomenon. Several authors believe triangulation can overcome problems of validity and bias (Bryman, 1988;
Patton, 1990; Mason, 1996; Arksey and Knight, 1999). Denzin (1970) explained that triangulation is not just restricted to using a variety of methods or a wide range of sources to obtain data, but also comprises investigators and theories as well (Denzin, 1970). Drawing on Denzin (1989), the four basic types of triangulation methodological, data, investigator and theoretical are described as follows.

*Methodological* triangulation means the use of a variety of methods to collect and analyse data. There are two types of methodological triangulation namely, ‘within method’ and ‘between methods’. ‘Within method’ triangulation employs the same method at different occasions in a single study. ‘Between methods’ basically uses a combination of methods to measure the same phenomenon, thus accessing the same phenomenon at different angles.

*Data triangulation* refers to the use of diverse data sources to investigate the same phenomenon. Different data may be obtained through the use of different methods, same method at different occasions, or from different sources.

*Investigator triangulation* means the combined efforts of different investigators to study the same phenomenon. Different individuals and individuals from diverse disciplines can bring different perspectives to the same phenomenon under study. By combining different researchers in a single study, the degree of bias generated by a single researcher may be reduced. Different viewpoints to the research can be drawn even when each researcher utilises the same method because each researcher may view and treat the data differently.
Chapter 5 Research Methodology and Design

Theoretical triangulation implies the adoption of multiple theories in a single study to gain a more holistic view of the research setting. Multiple theories in this sense are diverse perspectives and hypotheses about the research problem in question which may be generated from initial data analysis and insights from the research process itself. These hypotheses may in turn be tested out on the data. Triangulation can complement the weaknesses of qualitative or quantitative methodologies implemented alone. It is therefore important to adopt triangulation in any research to achieve a robust investigation into the research topic. In this study, triangulation methodologies are applied to create a robust research design.

5.6 Applications of triangulation in the study

The research design of this study is divided into two stages – Stage One and Stage Two is sub-divided into two phases (Phase I and Phase II) all of which will be discussed explicitly in section 5.10. At the exploratory stage of the study (Stage One), data were collected from three sources:

- The literature - journal articles and trade press.
- Observations of current operational processes in flight kitchens.
- Interviews with production manager who have good knowledge of the current operational practices of the flight catering industry.

Data was therefore collected from a rich range of sources and in effect, the consistency of data gathered from all the different sources was being cross checked. As discussed in the previous section, this method of collecting data from diverse sources is known as data triangulation.
At Stage Two, an approach had to be adopted to capture the influence of different process changes in the operations of flight catering units. So in Phase I, the quantitative approach of Data Envelopment Analysis (discussed previously) was adopted to take into account the factors that may be significant to the efficiency of a unit. The objective in Phase I is to determine efficient units and inefficient units amongst the data. Still the quantitative approach shows the inadequacy to give a true indication as to whether improvement in efficiency is explicitly due to elements of mass customisation.

As a result, Phase II comprises qualitative case studies of two efficiency and two inefficient units identified in Phase I to determine which are the distinguishing factors in the operational processes that give rise to improvement in efficiency relative to the two inefficient units. The qualitative case studies allow in-depth interviews to be carried out with key subjects who have sound knowledge of the operational processes to identify factors that are due to strategies such as JIT, modularity, lean production, and agile/flexibility which may be related to mass customisation to determine their impacts on efficiency. This combination of quantitative and qualitative methods is called ‘between methods’ triangulation. In this way, the drawback of using quantitative method for not being able to identify factors related to mass customisation is complemented by the qualitative case study approach and hence enhances the validity of this study.

5.6.1 Issues of reliability and validity

Reliability and validity are the two fundamental issues in establishing accuracy of data and repeatability of the results of the research. The importance of reliability and validity measures for both qualitative and quantitative approaches is underlined by several authors (Veal, 1997; Neuman, 2000; Babbie, 2004). In general, reliability refers to
whether a particular research technique will yield the same results if applied repeatedly to the same object (Babbie, 2004).

Reliability is the concern of the consistency in the measurement and therefore produces the same result on repeated occasions. Tull and Hawkins (1993) expressed reliability as an element that tests the issues of conformability and dependability. The purpose of reliability is to ensure that other subsequent researchers following the procedures described in an investigation or study and will realise the same findings and conclusions. As such, reliability aims to eliminate any errors or biases. To achieve reliability, questions were carefully worded and developed to eliminate respondents' biases. In addition, all interviews were recorded using a voice recording device to avoid bias.

Quantitative research is typified inherently to be more reliable than qualitative research due to the nature of the techniques used in data collection and analysis. Marshall and Rossman (1989:147) advocated this notion by saying “Positivist notions of reliability assume an underlying universe where enquiry could quite logically, be replicated”. They further stressed that reliability is more problematic for qualitative research because *interpretivism* assumes the social world to be constantly changing and therefore, the concept of replication is more difficult. Mason (1996:146) argued that reliability in the qualitative method can be improved by providing accurate accounts of procedures which can illustrate “thorough, careful, honest and accurate” data generation methods.

In consideration of issues in reliability just mentioned, at the exploratory stage of this study, three different sources are utilised for the collection of data. This triangulation of
data enforces the consistency of data and therefore enhances reliability because if results are consistent, it demonstrates that the same data collection technique yields the same results even from different sources. In Phase II of the main study used a case study protocol was used to assist interviews in the two efficient and two inefficient units. A case study protocol was described by Yin (2003) as a data collection tool that operationalises the research, acting as an action plan, and setting rules and regulations by which data would be gathered. In this way, the problem of reliability is alleviated whereby subsequent case study interviews can be quite easily replicated and followed.

Although repeatability and internal consistency of the findings can be enforced, but reliability does not ensure accuracy of the findings as validity does. Validity means that "the information collected by the researcher truly reflects the phenomenon being studied" (Veal, 1997:35). Drawing on Mason (1996:147), validity is concerned with "how well matched is the logic of the method to the kinds of research questions and the kind of social explanation a researcher intends to develop". Basically, a valid measure is one that measures or explains what has been intended to measure or explain and thus, deals with the appropriateness of the research method to the research question. Brinberg and McGrath (1985) emphasised the need for a high degree of congruence between what is being measured and the instrument that measures it to ensure that the essence of reality is accurately captured, analysed and reported. Silverman (1997) suggested there are two ways of checking validity of field research methods namely, “triangulation” and “respondent validation”. Yin (2003:34) proposed three types of validity measures to be considered whenever a researcher constructs a measurement instrument: construct validity, internal validity and external validity.
Construct validity is about establishing correct operational measures for the concepts being studied. This validity can be ascertained by collecting data from multiple sources, resulting in data triangulation. Hence, different sources provide several measures for the same phenomenon, and can ensure that the measures chosen for the dependent variable are correctly operationalised. The exploratory stage of this study enforces construct validity by using three different sources (observations, literatures, interviews) for data collection. Bias which may be generated by observations in the collection of data is now mitigated by cross checking with the other two sources.

Internal validity is concerned with establishing the notion that the causal model proposed really reflects the causal and not a spurious effect on the dependent variable. In other words, the role of internal validity is to ensure that any threats to validity have been identified so as to protect any interpretations or explanations from spurious effects, including confounding variables (Fink, 1995; Yin, 2003). Yin (2003) argued that internal validity is more essential for establishing explanations and causal relations, and not that important in the case of more descriptive and explanatory research. To ensure internal validity for this study, a stepwise DEA approach (refer to Figure 5.3) was undertaken to create a robust DEA model so that all significant factors that contribute to efficiency were taken into consideration and therefore any confounding effects were eliminated. Again, validity is ensured by removing any variables that may not be relevant to the efficiency measurement.

External validity is to establish whether the findings might be generalised to a domain outside the boundaries of the case. This validity also gives an indication of the fit between theoretical conclusions and empirical data. Yin (2003) suggested multiple case studies to enforce this type of validity so that generalisations of the research findings
can be applied to a wider group of situations. As Yin (2003:37) cited, “survey research relies on statistical generalization, whereas case studies rely on analytical generalization”. The analytic generalization refers to generalising the results or findings to theory, not to other cases. In Phase II of this study, case studies of two efficient and two inefficient units were carried out. By performing in-depth interviews, common features in the operational processes among the two efficient or two inefficient units can be determined and generalised.

5.7 Overview of research design

The research design represents the researcher’s plan and the structure of investigation that will be followed in the quest of answers to the research questions (Kerlinger, 1986). Yin (2003) defined research design as a logical process that connects the data to be collected to the initial research questions posed. Research design is simply a systematic drawn out blueprint that outlines the research approaches in order to guide the researcher in collecting, analysing and interpreting results. The investigations of this study were divided into two stages: exploratory study and main study. The research design begins with the exploratory study (Stage One) to determine if there are signs of mass customisation in flight catering industry so that further investigations could be carried out for the next stage. The next stage of research design is the main study which is sub-divided into two phases, namely Phase I and Phase II.

After the exploratory study, elements that are deemed to be important to efficiency performance are then tested on a cross sectional level (Phase I) whereby different flight catering companies or same company but different branches of production units are evaluated for comparison of performances. The final phase was pursued by case studies on two efficient and two inefficient units to further compare and understand what are
the elements that contribute to their efficiency score. The research flow design of each individual research stage/phase addresses specific aims as well as hypotheses. This is shown in Figure 5.1 and each stage/phase is further described explicitly in the following sections.

**Figure 5.1 Flow of research design showing aim and hypothesis in each research stage**

(Source: Author)
5.8 Research design for stage one – exploratory study

5.8.1 Aim of exploratory study

The aim of the exploratory study was to investigate the current operations management application in the flight catering industry in order to identify the operational mode that fits the flight catering business among five mass customisation modes proposed by MacCarthy et al. (2003). At the same time, relevant variables of production process in flight catering industry were identified in preparation for the Phase II study.

5.8.2 Research question

At the exploratory study, the research question that eventually led to the findings was, "Which mass customisation operational mode the flight catering industry belongs to?"

If a mass customisation mode does exist, then this implies that current operational processes of flight catering industry employ mass customisation in its practice. To answer the research question, the exploratory study examined six operational elements in MacCarthy et al.'s (2003) mass customisation mode relating to the operational processes of the flight catering industry. Then, a process mode was identified to suggest the operational mode of the flight catering industry.

5.8.3 Methodology of exploratory study

According to Neuman (2000), exploratory research is to determine the feasibility of conducting research and develop techniques for measuring and locating future data. The exploratory research therefore paves the way and makes sure the research is in the right direction before further stages of investigations begin. Due to the fact that not much is known about mass customisation decisions that can lead to improved operation efficiency, the exploratory research choice will be the most appropriate. Creswell (1994)
described how the design of an exploratory study begins not only with the selection of a topic, but also with the selection of a paradigm.

For the exploratory study, a qualitative approach was chosen for a number of reasons, which clearly relates to Creswell's (2003) definition of a qualitative study. The exploratory nature of the subjects and the fact that questions relating to operation processed polices and structures are not easily answered numerically, which are better expressed in works (Creswell, 2003). Mass Customisation is both a complex and holistic concept, thus the numerical focus of the quantitative approach is not conducive to the exploratory nature of this study, which is better expressed in words. Also, a qualitative study is best suited in this case to answer specific issues.

Hence, the exploratory study began with a qualitative approach to understand the current processes of flight kitchen operations. Observations of different flight kitchens were conducted in to gain in-sights of current operation processes in the flight catering industry. Different types of operations (job shop, batch production and mass procustion) that are employed by the flight catering industries were examined and their processes better understood at this stage. The observational visits to flight kitchens allow the induction of certain operational processes that may be mass customised. The exploratory investigation was then followed up with interviews of key members of the organisation to ascertain the identified variables, so as to suggest which mass customisation operational mode the flight catering industry belonged to. Interview is one of the methods of qualitative approach to obtain preliminary in-sights to understand and identify detailed information (Creswell, 2003). Data gathered from the interviews were then referenced to MacCarthy et al.'s (2003) five fundamental MC
operation modes to determine the mode of flight catering industry. The exploratory study is conducted and is presented in Chapter 6.

5.8.4 Sampling method

The definition of population to be studied is extremely important. In this context, samples were taken from catering professionals. However, non-probability sampling was used for this study because no probabilities were attached to how they were chosen for the study’s sample (Sekaran, 2000). The information required to carry out this research and the mode of mass customisation process system will be acquired through purposive sampling which is a form of non-probability sampling. Moreover, sampling requirements such as where to find the choice of subjects, who are in the best position to provide the information, will be used (Sekaran, 2000). By means of judgment sampling, which is one of the forms of purposive sampling, subjects who were in the best position to provide the information required were identified. Judgment sampling is concerned with judicious choice of selecting subjects from a specific target group for sampling. Specifically, the targets for the sampling of this exploratory study were professionals, who were senior managers that had in-depth knowledge of the operational process in the flight catering business. Eleven caterers that operated in both short and long haul routes in various parts of the world responded to the questionnaire. Caterers servicing short and long haul flights will inherently offer a more diverse product range.

5.8.5 Data collection

The preliminary data collection began with unstructured observations based on visits to catering companies in the United Kingdom (UK). From initial observations, a grasp on the general idea of the operation process in the in-flight catering industry was achieved.
Further visits to these flight kitchens provided a clearer understanding of the processes and knowledge for the identification of factors that may be relevant to the aims of this study. The next stage of data collection was at the International Travel Catering Association (ITCA) trade show. Because of the importance of the flight catering industry, ITCA was formed in the United Kingdom in 1980. ITCA is a professional association serving the needs of all member companies in the industry - scheduled and charter carriers, specialist catering companies, and supplier companies of equipment, food and beverages used in fulfilling passenger requirements. ITCA held its first conference and trade show in 1982 and has continued this annually ever since - usually in a different European location each year, and attended by well over 1,000 delegates. Due to the fact that ITCA organise the largest flight catering event each year in Europe, all major airline caterers and suppliers will be present. Thus, data collection was targeted at the ITCA trade show, which was held in Nice, France in February, 2004. Due to time constraints, scheduling of the interviewers was arranged. During the interview process, questionnaires were filled out by distributors and notes were taken for open ended questions. With the assistance of a voice-recording device, any bias in answering the questions was avoided.

5.8.6 Data analysis

From the gathered primary data, content analysis was carried out to interpret the trends associated with the operations process in respect to the flight catering industry. According to Neuendorf (2002:36), content analysis is “a technique which aims at describing, with optimum objectivity, precision, and generality, what is said on a given subject in a given place at a given time”. Riffe et al. (1998) emphasised the role of centrality in the communication process that content analysis can bring in building theory on communication effects and processes.
Content analysis is a systematic, repeatable method for the identification of contents from texts or words that leads to the deduction of inferences for a particular investigation or study (Berelson, 1952; Krippendorff, 1980; Weber, 1990). At a broader level of definition, Holsti (1969:14) stated that content analysis is "a technique that makes inferences by objectively and systematically identifying specified characteristics of messages". According to Babbie (2004), content analysis is a non-obtrusive research meaning the researcher does not influence the subject to determine his motivation or responses. Instead, the researcher codes the raw data which can be texts, messages or images to gain insights on social processes.

In the exploratory study, the objective was to determine the operational processes of the flight catering industry in relation to MacCarthy et al.'s (2003) mass customisation fundamental operational processes. From Figure 3.3 in section 3.10 of Chapter 3, only three processes namely, product design/development, product validation and manufacturing engineering and order fulfilment realisation vary for different modes while the other three processes (order taking/co-ordination, order fulfilment management and post order process) are fixed for all modes. As such, by querying the three processes that vary, a conclusion was drawn as to what mass customisation operational mode does the flight catering industry belonged. The next step was to design questions that pertained to the three processes. Appendix 1 shows the constructed questionnaire. After which content analysis was conducted to induce the contents from the transcribed interviews that were related to the three processes that vary (see Appendix 2).
5.9 Research method for Stage Two – Phase I

The objective of Phase I was to compare efficiencies of cross sectional flight catering units using DEA. The objective of Phase I was to compare efficiencies of cross sectional flight catering units in order to separate out the efficient units from inefficient units amongst the data by Data Envelopment Analysis (DEA). The concept of DEA is explained in greater details in the next section. Cross sectional in this sense means flight catering units of different companies or similar catering units within the same company. In this phase, two efficient and two inefficient units identified by DEA were selected as case studies for the next phase (Phase II) in order to understand why the characteristics being identified in relation to mass customisation render the units efficient.

5.9.1 Concept of DEA

The concept of Data Envelopment Analysis (DEA) was introduced in section 2.3.2 of Chapter 2. In recent years, DEA has been adopted as the principal technique for evaluating performances applied to a great variety of industries ranging from hospitals, educational institutions, banks etc. Charnes, Cooper and Rhodes first introduced the concept of DEA in 1978. Originally, Charnes et al.’s research was aimed at non-profit organisations so that they could discount economic weighting factors such as market prices. Since the introduction of DEA, successes in the applications of this method had been reported in both public and private sectors, especially when accounting and financial ratios are of little or no value (Charnes et al., 1994; Norman and Stoker, 1991). In contrast to other performance measurement techniques, DEA is a multivariate, non-parametric technique that benchmarks units by comparing their ratios of multiple inputs to produce multiple outputs at the same time and by using the concept of performance frontier (Avkiran, 1999).
A acceptance of DEA is widespread because all factors that affect the performance of a
certain unit are taken into account. Multiple inputs and outputs that are considered
relevant to the performance of a unit are all factored into DEA. This form of
measurement is known as the ‘total factor performance measurement’ as opposed to
‘partial factor measurement’ where only partial factors are evaluated which will then
result in an inaccurate efficiency score. This multivariate characteristic of DEA allows
multiple inputs and outputs to all be considered and evaluated at the same time. Unlike
other parametric performance evaluation techniques where knowledge of the functional
form of the relationship between the output and the input is necessary, DEA requires no
such a priority. The assumption of linear programming allows DEA to cope with large
numbers of variables and constraints and this relaxes the requirements that are
encountered. The use of parametric techniques such as regression is limited to only a
few inputs and outputs because the technique employed will otherwise encounter
difficulties.

Typical statistical approach tends to measure performances by evaluating units relative
to an average unit. In contrast, DEA is an extreme point method which means each unit
is compared with only the "best" units. In the DEA literature, a unit is known as a
Decision Making Unit (DMU). DMUs are used to describe a collection of departments,
divisions or administrative units which have common inputs and outputs. To illustrate
the extreme point method, consider a given DMU, A for example, capable of
producing O(A) units of output with I(A) inputs, then all other DMUs should be able to
achieve the same if they were to operate efficiently. By the same token, if unit B is
capable of producing O(B) units of output with I(B) inputs, then all other units have the
capability to achieve this same efficiency if judicious decisions are undertaken in the
management of these units' operations. A composite unit formed by the combinations
of DMUs A, B, and others having composite inputs and composite outputs is also called a virtual unit since it does not always ‘physically’ exist.

The crux of DEA analysis lies in finding the ‘best’ virtual unit for each real unit. The ‘best’ unit is benchmarked as the most efficient unit for comparison with other DMUs. If the virtual unit outperforms the original unit by either producing more output with the same input or producing the same output with less input than is required, then the original unit is deemed inefficient. This is illustrated by an example of a two-output, one input DEA model depicted in Figure 5.2.

**Figure 5.2 A two-output, one input DEA model**

(Adapted from Charnes et al., 1994:4)

As illustrated in figure 5.2, DMUs B, E, F and G are regarded as the most efficient units amongst all other units. The line joining DMUs B, E, F and G thus form the efficient frontier representing the achieved efficiency. Any units that fall on any points on this frontier thus have an efficiency score of 100%. On the other hand, all other
units, for example DMUs A, C and D that are being enveloped and fall short reaching this frontier are deemed as inefficient. Hence, the frontier serves as a ‘benchmark’ to other inefficient units. The dotted line shows that DMU D has to move to the position of the frontier where DMU F is, in order to be considered efficient. The strengths of DEA are summarised as follows:

- Multiple inputs and outputs can be accommodated into DEA.
- No assumption of functional form relating inputs to outputs is required. The function is generated in DEA from the data set of observed operating units.
- Units are compared directly with a peer or a combination of peers.
- The units of inputs and outputs can be different. This is possible because of the relative efficiency principle that DEA adopts.
- The computation of efficiency is relative to the most efficient DMU and thus is independent of the units of measurement. This allows greater flexibility in the selection of inputs and outputs that contribute to the performance of a unit.

So far, only the advantages of DEA have been discussed but its strengths can potentially be its limitations too. DEA is ideal for estimating how efficient a unit is compared to other peers but not compared to an optimal efficiency. This limits the ability of DEA to deduce how well a unit is performing compared to a "theoretical maximum." Unlike a regression based approach, DEA is a non-parametric technique which assumes the data are free from measurement error. As a result, it is extremely sensitive to unreliable data since the efficiency frontier is constructed based on the underlying assumption that the unit/units are efficient. This results in over or under estimating other units compared to this frontier. For results to be comparable, it is paramount to use a homogeneous group
of DMUs in DEA. This sets a constraint on DEA from comparing units that are from different operational and production backgrounds.

In light of these limitations, the determination of using DEA as a tool then depends on the application. For this study, it is necessary to compute and compare the efficiencies of flight caterers. As such, we are comparing units that have the same operation and production variables. This fulfils the constraints of having a homogeneous group of units in DEA. Also, we not concerned with optimal theoretical efficiency – DEA is being used only to sort the units according to their efficiency so that cast study operations may be selected. The assumption of error free measurement data by DEA can be resolved by a systematic stepwise approach which will be discussed later in section 5.9.4.

5.9.2 Defining variables in the flight catering industry

In mathematical terms, a variable is something that is subject to variation. Inputs and outputs in the context of a production unit, for example, the output is sales and the input is labour hours, and can be classified independent variable and dependent variable respectively. The outcome of an output depends on the input and hence the name dependent variable and independent variable. The accuracy of the efficiency score computed by DEA depends on the judicious choice of inputs and outputs that are relevant to a unit. In essence, DEA is just a mathematical computing expression to evaluate the efficiencies of production units and has no discrimination power on what are the relevant or irrelevant variables. The choice of inputs and outputs for DEA analysis solely lies in the researcher’s judgement and any irrelevant inputs and outputs can distort the efficiency results. In consideration of this, Phase I adopted a two tier approach to select relevant inputs and outputs.
The first step to identify key inputs and outputs was based on observational visits, literature reviews and interviews conducted at the exploratory stage. To ensure reliability in the identification of inputs and outputs, a total of five visits to three different flight kitchens in the UK were conducted. This was followed by a discussion with an expert in the flight catering industry to further streamline or to include important variables which might have been left out by the researcher.

Under volume, the outputs of interest are the number of meals produced and the number of tray set layout. The volume of tray set layout provides an insight to the logistics of the operation. Hence, the relationship between tray set volume and number of meals produced gives a measure of outsourcing and order fulfilment realisation.

For variety, the outputs are simply the number of different airlines served, proportion of different classes (first, business, and economy) and number of charter meals. As the number of airlines served rises, there will be more product designs, more equipment to handle and so on, therefore this factor has a direct impact in the efficiency of the unit. The breakdown between different types of meals (first, business, chartered class meals) is concerned in dealing with variety. For example, a caterer may be serving one airline but producing four different sets of meals. Charter airlines are difficult to cater for because they come and go in an unscheduled, unplanned way which causes a disruption in the production flow. However, the output of the caterer will be highly customised.

On the input side, this study is concerned with the total labour hours for setting up trays, size of the production unit and total labour hours for food production staff. The size of the production unit may have an impact because the bigger the size, the greater is the amount of movements and transportations around the area which then delays the
production flow. On the other hand, the kitchen may be small but its environment is badly organised or too crammed which will be deemed as inefficient as well. Table 5.2 shows the classification of inputs and outputs under volume and variety.

**Table 5.2 Classification of inputs and outputs**

<table>
<thead>
<tr>
<th>Volume</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outputs</td>
<td>Inputs</td>
</tr>
<tr>
<td>(1) Total number of tray sets</td>
<td>(1) Total number of full time employees</td>
</tr>
<tr>
<td>(2) Total number of hot meals</td>
<td>(2) Number of full time employees in food production</td>
</tr>
<tr>
<td></td>
<td>(3) Total labour hours</td>
</tr>
<tr>
<td></td>
<td>(4) Total labour hours for setting up tray</td>
</tr>
<tr>
<td></td>
<td>(5) Total labour hours for hot food production</td>
</tr>
<tr>
<td></td>
<td>(6) Size of production unit</td>
</tr>
<tr>
<td>(1) Number of different airlines served.</td>
<td>(2) Number of first and business class meals</td>
</tr>
<tr>
<td>(3) Number of charter airline meals</td>
<td>(4) Average number of flights served</td>
</tr>
</tbody>
</table>

**5.9.3 Stepwise approach to selection of relevant variables**

In many cases, the researcher may gather as many variables as possible in order to capture the essence of the production plant under test. Especially for areas of exploration that have not been previously reported, the researcher has to rely on judicious judgment in selecting the variables and frequently confounding variables which are irrelevant and may be wrongly included in the model. It has been reported by several pieces of literatures that undesirable variables result in bias in efficiency scores computed by DEA. Stolp et al. (1990); Smith (1997); Pedraja-Chaparro et al. (1999) and Dyson et al. (2001) all highlighted the effect of including irrelevant variables into the DEA model where actual inefficient units may appear to be 100% efficient under the misspecification of variables.

To solve this issue, a stepwise method (Sengupta, 1988; Norman and Stoker, 1993; Parkin and Hollingsworth, 1997; Sigala et al., 2005) is commonly applied to DEA. Sigala et al. (2005) presented a stepwise DEA approach to solve this problem by first
using aggregate variables in the model that are deemed with confidence to have efficiency contribution. After the efficiency score was computed with DEA, the aggregate variables were decomposed into their disaggregate variables to see if any strong correlations were found with the DEA efficiency score. This method therefore eliminates any uncorrelated variables with efficiency, retaining only those relevant variables presenting a model that only consists of significant variables. Greene (1993) pointed out that the classical inference procedures about the variables breaks down after the first step by the stepwise principle and therefore allows one to easily identify the important variables.

Norman and Stoker (1993) proposed a stepwise approach to DEA by initially considering a simple model that consists of one input and one output. Through an iterative process whereby a single input or output is sequentially added into the model until no more inputs or outputs show any strong correlation with the efficiency score, a robust DEA model is created. The strength of this technique lies in the fact that it can justify the selection of inputs or outputs into the model to establish a consistency with the initial thought out efficiency measure.

In general, the stepwise approach iteratively measures the efficiency of significant inputs and outputs identified up to that step. To include other important inputs/outputs, a statistical correlation test is conducted to determine if any strong correlation with the measure of efficiency exists. Following that, these inputs/outputs are incorporated back into DEA to compute the efficiency score and this process is repeated until no further inputs/outputs are observed. Therefore, all significant inputs/outputs have been accounted for. The stepwise approach undertaken in Phase 1 of this study follows that of Norman and Stoker (1993) and is described in details as follows: In the first step of
the stepwise approach, a pair of single inputs and outputs deemed with confidence to be significant to efficiency, are incorporated into DEA and efficiency scores calculated. Then, a statistical test, Pearson correlation is conducted to see if there is any significant correlation between other inputs/outputs and the efficiency score. If there is a strong correlation between them, the highest correlated input/output would be included in the new DEA model and efficiency scores computed again with the added variable. The process is repeated until all the significant inputs/outputs are incorporated in the DEA model. The whole approach of this analysis is depicted in Figure 5.3.

**Figure 5.3 Approach to analyse data using stepwise DEA to determine significant inputs and outputs.**

(Adapted from Trait, 1999)
5.9.4 Sample size and data collection

Because DEA is based on the assumption of error free data, the sampling size of empirical data gathered plays an important part in the determination of accurate relative efficiency measurement. If there happen to be measurement errors, for example, some data are more efficient or less efficient than they really are, then there will be a shift in the position of the efficiency frontier. Since all other inefficient units are referenced to this frontier, efficiency measures deviates from actual efficiency results. This problem is magnified if the sampling size is small. Hence, a large sampling size is paramount to ensure the above mentioned problem is alleviated. One point to note though is that measurement errors are not eliminated but are reduced with a large sampling size. A bootstrapping technique can resolve the issue of errors in measurements.

Knowledge of sampling distribution can correct for sample bias. There are two approaches to estimate this distribution: (i) analytic asymptotic analysis and (ii) bootstrap technique. Although it is possible to analytically derive the asymptotic sampling distribution (Gijbels et al., 1999) but currently there only exists results for single input, single output case and there is no clear generalisation about how to apply this to multiple inputs and outputs. Alternatively, the bootstrap method can approximate the sampling distribution which is a statistical re-sampling technique first introduced by Efron (1979) and Efron and Gong. The bootstrap is a well established tool to measure sensitivity of distribution variation in cases where sampling distribution is difficult or impossible to obtain analytically. Simar and Wilson (1998) developed a bootstrap procedure especially tailored for DEA. However, programming codes of the bootstrap technique is not incorporated in existing DEA software. Thus, codings have to be self written which then increases the complexity of using this technique. Based on the
experiences and empirical findings of DEA practitioners, the number of samples should be (Dyson et al. 2001:248; Avkiran, 2002):

\[ K \geq 2 (N+M) \]

Where \( K \) is the number of units used in the analysis, \( N \) and \( M \) are the number of inputs and outputs respectively. The rationale behind is because one would expect \( N \times M \) possibilities that DMUs can be efficient which then implies that the number of units in the set should be substantially greater than \( N \times M \), in order to achieve proper discrimination between units (Dyson et al., 1990). Sigala et al. (2005) too suggested that the sampling size should be significantly greater than \( (N \times M) \) to obtain rational DEA results.

Initially, contacts of 345 international flight catering units were gathered from the Momberger world directory of flight kitchens database released in Autumn 2004. Momberger is a private company that surveys flight kitchens throughout the world and lists information such as the catering unit’s production output, the size of the catering unit, number of employees, etc. After obtaining the contacts of flight catering units from the Momberger database, they were approached by email and fax to collect the required variables. However, only 23 flight kitchens replied and only 19 units have complete usable data. However, in consideration of the requirement for sample size to be substantially greater than \( (N \times M) \) mentioned earlier, the number of samples needed for proper DEA discrimination should be much greater than 36 units for 6 inputs and 6 outputs defined for this study. Hence, another way was sought to obtain more samples. The alternative approach used data directly from the Momberger world directory of flight kitchens 2004 database, which has given information on 5 variables. In total, the Momberger database has a comprehensive listing of 345 international flight kitchens but only 134 flight kitchens have complete information on the 5 variables. In this case,
the problem of insufficient sampling size was resolved but at the expense of a smaller number of variables that represent the general production model of the flight kitchens.

5.9.5 Approach to analyse data using DEA

In order to discuss what are the different modes to analyse inputs and outputs using DEA, certain terminologies and concepts need to be clarified and explained. The two most widely implemented models are the CCR and BCC models in DEA. The CCR model was named after Charnes, Cooper and Rhodes (1978) developers of this model. This model will generate a linear frontier because of the underlying constant return to scale assumption. In other words, units are able to linearly scale inputs and outputs without increasing or decreasing efficiency. Banker, Charnes and Cooper (BCC, 1984) extended the CCR model to accommodate operations that exhibit variable return to scale. The frontier is formed by a piece-wise linear connection of efficient units. Variable return to scale means that the relationship between the input and output is no longer linear. Scaling of inputs and outputs in this case causes a change in the efficiency. Typical CCR and BCC models are illustrated in Figure 5.4.

Figure 5.4 CCR and BCC Frontiers

(Adapted from Cooper et al., 2000:87)
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Farrell (1957) stated that the overall efficiency can be broken down into allocative and technical efficiencies. Technical inefficiencies mean that inputs are not properly utilised and also from the fact that units are not operating at their optimal sizes (scale inefficiency). Allocative inefficiencies arises from sub-optimal allocation of inputs. There are two optimisation modes in DEA, namely input minimisation and output maximisation. Input minimisation concerns the amount of inputs that can be reduced while maintaining output levels. As for output maximisation, it can either imply in an increase in outputs or a reduction in inputs depending on which variables are evaluated. The CCR model which is based on the assumption of constant return to scale will be employed for this study. The reason for this choice is because the study is only interested in identifying efficient and inefficient flight catering units for further case study investigations on those identified units. Scale inefficiency is not of interest here because we want to compare catering companies of different scales. Hence, the CCR model is adequate for the purpose of this study. Input minimisation is assumed to be the optimisation mode in DEA since lean production and agility/flexibility are approaches to reduce wastage in the operational processes of a unit while its output level is maintained.

5.10 Research Method or Stage Two – Phase II

Having identified the efficient and inefficient flight caterers by DEA in Phase I, a qualitative approach by means of case study interviews with key people in the organisation was necessary to ascertain and gain in-depth understanding of why certain characteristics of MC have such impacts on the efficiencies of the two top efficient and two least efficient flight catering units. The aim of this phase is to enable one to establish a generalisation of certain elements in MC that were adopted in the flight catering industry that lead to better efficiency.
5.10.1 Case study methodology

Case study is defined by Yin (2003:13) as an in-depth investigation to gain comprehension of a “contemporary phenomenon within its real life context especially when the boundaries between phenomenon and context are not clearly evident”. In general, case study is preferred in situations when the researcher has little control over events, especially if the phenomenon under study is within some real-life context. Unlike the survey which is a quantitative method of research, case study focuses on seeking answers that cannot be gathered from surveys, for instance to understand how and why the phenomenon of the entity under study exists. Case study can take the form of quantitative statistical research or qualitative descriptive research, or even a combination of both (Burns, 1997).

Depending on the circumstances, the adoption of a case study method will be determined. Case studies using qualitative methods are employed when the research question requires answers to a real life intervention in detail, where the focus is on how and why the intervention succeeds or fails (Patton, 1990). Yin (2003) further identified three different types of case study: exploratory, descriptive and explanatory. The nature of this classification depends on whether they are used to answer what, how and why questions respectively. Yin (2003) also categorized 5 components that are important to the case study research design: a study questions; its propositions (if any); its unit of analysis; the logic of linking the data to the propositions; and criteria for interpreting the finding. Tables 5.3 presents Eisenhardt’s (1989) suggested steps for building process of case study research. Followed by Eisenhardt’s advice, a common case study pattern can be established by case study design; preparing for data collection; conducting case studies; analyzing data; and finally reporting (Yin, 2003).
### Table 5.3 Steps for building process of case study

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting started</td>
<td>Definition of research question possibly a priori constructs</td>
</tr>
<tr>
<td>Selecting cases</td>
<td>Neither theory nor hypothesis specified population.</td>
</tr>
<tr>
<td></td>
<td>Theoretical, not random, sampling.</td>
</tr>
<tr>
<td>Crafting instruments and</td>
<td>Multiple data collection methods</td>
</tr>
<tr>
<td>protocols</td>
<td>Qualitative and quantitative data combined</td>
</tr>
<tr>
<td></td>
<td>Multiple investigators.</td>
</tr>
<tr>
<td>Entering the field</td>
<td>Overlap data collection and analysis, including field notes.</td>
</tr>
<tr>
<td></td>
<td>Flexible and opportunistic data collection methods.</td>
</tr>
<tr>
<td>Analysis data</td>
<td>Within-case analysis.</td>
</tr>
<tr>
<td></td>
<td>Cross-case pattern search using divergent techniques</td>
</tr>
<tr>
<td>Shaping hypotheses</td>
<td>Iterative tabulation of evidence for each construct.</td>
</tr>
<tr>
<td></td>
<td>Replication, no sampling, logic across cases.</td>
</tr>
<tr>
<td></td>
<td>Search evidence for “why” behind relationships</td>
</tr>
<tr>
<td>Enfolding literature</td>
<td>Comparison with conflicting literature.</td>
</tr>
<tr>
<td></td>
<td>Comparison with similar literature.</td>
</tr>
<tr>
<td>Reaching closure</td>
<td>Theoretical saturation when possible.</td>
</tr>
</tbody>
</table>

(Eisenhardt, 1989:533)

A descriptive case study is advantageous when the research goal is to describe the occurrence of a phenomenon or when the research is to be predictive about certain outcomes (Yin, 2003). Accordingly, this study adopted a descriptive approach to explain in-depth the current practices of the flight catering industry and hence suggest the possibility of MC elements in operational processes that attribute to higher efficiency. Jensen and Rodgers (2001) proposed a typology of case studies shown in Table 5.4.
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Table 5.4 Typology of case study by Jensen and Rodgers

<table>
<thead>
<tr>
<th>Type of case study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snapshot case studies</td>
<td>Detailed, objective study of one research entity at one point in time. Hypothesis testing by comparing patterns across sub-entities (ex., comparing departments within the case study agency).</td>
</tr>
<tr>
<td>Longitudinal case studies</td>
<td>Quantitative and/or qualitative study of one research entity at multiple time points.</td>
</tr>
<tr>
<td>Pre-post case studies</td>
<td>Study of one research entity at two time points separated by a critical event. A critical event is one which one the basis of theory under study would be expected to impact case observations significantly.</td>
</tr>
<tr>
<td>Patchwork case studies</td>
<td>A set of multiple case studies of the same research entity, using snapshot, longitudinal, and/or pre-post designs.</td>
</tr>
<tr>
<td>Comparative case studies</td>
<td>A set of multiple case studies of multiple research entities for the purpose cross-unit comparison.</td>
</tr>
</tbody>
</table>

(Adapted from Jensen and Rodgers, 2001:237-239)

Ultimately, this study established common trends among efficient flight catering units as well as trends in inefficient units. Multiple case studies are necessary to compare similar units and relate common features found in them. Therefore the type of case study employed in this study apart from being descriptive must also be multiple, which is classified by Jenson and Rodgers (2001) as comparative case studies (see Table 5.4). To approach a holistic description of the entity being evaluated, this case study had adopted comparative case studies as they are valuable in establishing concepts among different firms but of similar nature in business.

5.10.2 Selecting cases

Case study is not a sampling research and should follow a replication, not a sampling logic. Major researchers in the field that include, Feagin et al. (1991), Stake (2000) and Yin (2003) all asserted that as a fact. To address external validity, Yin and Eisenhardt
were referred by using replication logic in selecting case studies. Case study relies on, however, analytical generalization (Eisenhardt, 1989; Yin, 1993), not statistical generalization as with experimental hypothesis-testing research (Kuo, Dunn, and Randhawa, 1999). If replication of several cases exists with similar results, then consistent generalisation can be developed over multiple cases or even studies resulting in a very robust finding. According to Ginsburg (1989), exemplary cases are selected to reflect strong positive examples of the phenomenon of interest. Yin and Eisenhardt commented that the total number of cases “a number between 4 and 10 cases usually works well” (Eisenhardt, 1989:545). For this study, two high and two low performing flight catering units were selected as exemplary cases based on DEA analysis in Phase 1 which enabled differentiation between efficient and inefficient units. To enable the research to develop a full picture of the organisation idiosyncrasies and allow the author to investigate what the elements of operational processes are related in MC which affect the efficiency score, multiple case studies are the appropriate and realistic approach for doing this study. In addition, examination and cross-check of findings to gain an in-depth knowledge and effect relations of the flight catering units were realised.

5.10.3 Case study data collection

Data collection has involved many topics that all aims for one purpose, to “get information”. These subjects, according to Weerd-Nederhof (2001) include: design, strategy, skills, linking of qualitative and quantitative data, management issues like data management, staffing and time planning, agreement with study participants (Miles and Huberman, 1994), instrumentation and protocols, entering the field (including gaining access, and management of data collection and some ethical issues), etc. Miles and Huberman (1994) also suggested some ethical issue for the agreement with study participants cited by Weerd-Nederhof (2001):
Chapter 5 Research Methodology and Design

- How much time and effort will be involved?
- What kind of data collection involved (e.g. observation, interviewing, journal writing, life histories)?
- Is participation voluntary?
- Who will design and steer the study?
- Will materials from participants be treated confidentially?
- Will participants' anonymity be maintained (as well as units' anonymity)?
- Who will produce descriptive and explanatory products?
- Will participants review and critique interim and final products?
- What benefits will accrue to participants—both information and researchers?

Multiple data collection methods are known as triangulated research strategy in case study to ensure the validity of findings (Jick, 1979; Stake, 1995; Stake, 2000; Yin 2003). Yin (2003) identified several data sources of evidence that can be used in case studies shown in Figures 5.5. In these multiple case studies, sources of data that were ideally intended to collect data include the company's profile, operations flight schedule, inventory list, and menu booklist. But, due to the issue of confidentiality, these data may not be able to be assessed. Hence, data was unable to be assessed, and information/interviews had to be conducted in the field. By using multiple sources of data, a stronger substantiation of theory is achieved through triangulation, where validity is ascertained.
As case study research is time consuming and costly, a case study protocol is necessary to act as a data collection tool. Two types of case study aspects are case study protocol and data collection process. Protocol includes the instrument and procedures and the general rules should be followed in using the instruments (i.e. the interview questions) (Kuo, Dunn and Randhawa, 1999). A case study protocol is defined by Yin (2003) as a tool that acts as an action plan, setting rules and procedures by which data is gathered. Stake (1995) proposed that protocols are used in case study to ensure accuracy and provides a systematic research flow to collect the data.

As emphasised by Yin (2003), a case study protocol is essential for multiple case studies which allows other researchers to trace the path where data is collected for research replication and verification. For reliability concern, the research process should follow case study protocol to guide through the entire process. Yin (2003) stated that the protocol is a major tactic in increasing the reliability of case study research and is intended to guide the researcher in carrying out the case study. Thus, the case study protocol is able to allow other researchers to know how the data is collected and how the analysis is made. The characteristic of case study research is the combination of data
collection methods, such as interview, questionnaires, and observations (Kuo, Dunn and Randhawa, 1999). With the protocols defined, a qualitative research method was developed to gather data from the flight catering units of analysis. The method was in the forms of interviews and observational audits, concerning questions that were related to MC elements. This research of protocol (see Appendix 3) was not only designed based on the literature review but also was inspired from the previous six times catering visiting during 2003 - 2004. Furthermore, the protocol also was reviewed by the author’s former airlines company’s colleague who was working in the China Pacific catering as production manager prior to fieldwork study. The following sections described each of the methods in greater details.

5.10.4 Interview

Interview allows a researcher to personally address a series of questions to respondents (Macionis and Plummer, 2002). Walsham (1995) opined that interviews enable the access to interpretations of participants concerning the course of actions they took in certain events as well as their views of themselves and other participants. The advantage of interview enables the researcher to examine after gathering the interpretation of participants in an unbiased way, and allows carefully intended analyses to be made.

Denzin and Lincoln (2000) classified interviews into three major types, namely, structured, semi-structured and unstructured. In a structured interview, specific goals and questions for the interviews are detailed before the interview process commences, thereby providing guidelines and structure. The researcher asks clearly defined questions in a structured interview in contrast to an unstructured interview where some of the questionings are led by the responses of the participant. Specifically, a structured
Chapter 5 Research Methodology and Design

interview is adopted in the form of open questions if the objective is to retrieve information from experts in the subject interviewed. This approach provides more detailed information on the problem under investigation. However, a structured interview is only suitable where there are people who are familiar with the topic that is studied. On the other hand, unstructured interviews take the form of open questions to allow discussions to be open in order to provide a general understanding of the problem. During an unstructured interview process, it is likely that audio/video tapings of the expert may be taken in the course of performing tasks. The expert is not required to give explanations on the decisions taken.

Deductions are made from the recorded tapes by the interviewer to search for key variables and rules concerning the research problem. As the concept of MC is relatively new and the fact that no existing article clearly defines what exactly are the elements of MC, professionals in the flight catering industry may not know if strategies in their operational processes for instance agile/flexibility, JIT, modularity are constituents of MC. As such, an unstructured interview is employed in this study to deduce from observational audits and voice recorded tapes if strategies in their operational processes are attributable to MC.

Interviews in the case studies employed snowball sampling. This is a form of judgment sampling and was adopted in this phase. This method relies on the ability of the researcher to first locate individuals believed by the researcher to have the desired characteristics (Churchill, 1999). The individuals approached by the researcher then identify others who they believed to have a better knowledge in the subjects than themselves. The process continues until the key person who can provide answers to the study is identified. The person to be approached in the initial stage is the general
manager of the flight catering unit. Due to time constraints, each unit manager was interviewed approximately 50 minutes. Each department manager was introduced by the unit manager while doing a short tour of the flight unit. Likewise, the unit manager referred other persons in his/her organisation whom he/she thinks have a better knowledge of the subject being interviewed. If the other person could not provide the answer, another person would be identified, and the process continued until the person who can provide the answer was found. The employees interviewed included production manager, equipment manager, operation manager, chefs, and assembly workers.

5.10.5 Observation

Observation is the process of watching the actions of participants to gather data required. According to Cooper and Emory (1995), observational approach is a scientific inquiry that when systematically planned and executed provides a reliable and valid account of what happened. Kumar (1999) proposed two types of observations: participant observation and non-participant observation. In participant observation, the researcher takes part in the activities of the participants with and without them knowing that they are being observed. The rationale behind this approach is to enable the researcher to gain understanding as well as to experience what the participants had gone through. The other type of observation is non-participant observation. Here, the researcher is not involved in any activities of the participants and remains a passive observer. The researcher listens, watches and records the behaviours of participants and after a few observations, conclusions can be drawn.

Operational processes in the flight catering units were observed by the method of non-participant observation to understand the process work flow and interactions
between the different processes. The flow of observation began in the goods inward area, food production area, assembly area, equipment store, despatch and loading areas, washing area, and operations department. In addition, audits were conducted to record quantity variables for instance, quantity of received goods, number of meals / trays setups, and number of equipment in storage. All these data obtained provided additional source of data collection which enhanced the validity of this study.

5.10.6 Data analysis

There are four steps to be included in data analysis process; data reduction, data display and conclusion drawing, and verification (Miles and Hubermann, 1994). “Analysing data is the heart of building theory from case studies, but it is both the most difficult and least codified part of the process” (Eisenhardt, 1989). Patton (Patton, 1990), however, stated the challenge of data analysis of qualitative data as “make sense of a massive amount of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveals”. Nevertheless, researchers usually have to rely on their own judgement, experience, and insight to process the data analysis step (Kuo, Dunn and Randhawa, 1999).

Within-case analysis and cross-case analysis are two major procedures for data analysis. Within-case analysis involves organizing the data by specifying cases for a depth down study and is able to reduce the overwhelming data volume (Eisenhardt, 1989). He also states that within-case analysis typically involves detailed case study write-ups for each site, often simply pure descriptions, but longitudinal graphs and tabular displays have been used. She also mentions some tactics for cross case pattern searching (Eisenhardt 1989). As soon as the data collection and displays for each case are completed, the cross-case patterns search will begin. Cross-case analysis sometimes
Chapter 5 Research Methodology and Design

may cross a line to the within-case analysis area in a real world scenario. Pattern search by cross-case method will enable researchers to look at data not only by initial impressions but also by diverse ways (Eisenhardt, 1989). Patton stated that qualitative data patterns can be represented in various ways, such as dimensions, categories, classification schemes, and themes (Patton, 1990).

Interviews were tape recorded and transcribed to electronic text format. A protocol interview was conducted with a set of questions followed by observations and audits of the operational processes. All the information was collected by reading the interview transcripts (see Appendix 4). After each unit was visited, reports were written on each of the four cases in order to enhance the validity and reliability of the information. The structure of the case report was referred to the current operational process of flight catering unit sourcing from the Chapter four’s lecturer review. Miles and Huberman (1994:91) advise that “visual format that presents information systematically, so the user can draw valid conclusions and take need action”. Hence, the results of data were sequence displayed in the individual report followed by the protocol for easy interpretation of within case analysis and cross case analysis. However, the descriptive reports contents were confirmed by the flight catering unit’s manager. Both analysis methods were then used to examine the transcribed data gathered from the interviews to look for similarities (within-case) and differences (cross-case).

5.11 Conclusion

The design of research methodology to conduct this study has been discussed. A combination of qualitative and quantitative approach were utilised, forming a triangulation of methods to ensure validity of the method used for the investigation. Two stages of research design, namely exploratory and main studies were outlined.
Exploratory study is a qualitative approach that involved literature review, observations of flight catering units and interviews with key members to understand the current operational processes of flight kitchens that lead to the induction of the mass customisation operational mode the flight catering industry belonged.

After establishing the fact that MC does exist in flight catering operations, the next research stage was pursued. The second stage is divided into two phases, Phase I and Phase II. At Phase I, variables that were related to volume and variety in the flight catering industry were defined and collected. Ultimately, this study investigates whether variables of volume and variety render a flight catering unit efficient which in turn advocated that MC could solve the issues of high volume and high variety. Efficiencies of flight catering units were computed using DEA which took into account the multiple variables obtained. Having separated out efficient and inefficient catering units by DEA, two top efficient and two least efficient units were selected as multiple case studies for the final phase (Phase II).

In particular, the research design sought to determine and understand important factors (inputs and outputs) in the operational process that have significant contribution to the performance of the flight catering industry. The next chapter presents the results of each stage and discusses the implications of the findings in terms of the study’s research aims.
Chapter 6 Stage One - Findings of Exploratory Study

6.1 Introduction

In this chapter, the appropriate MC mode for the flight catering industry was identified; by matching flight catering operations in relation to the processes in a typical MC environment proposed by MacCarthy et al. (2003). Specifically, the proposed processes were order taking and co-ordination, product development and design, product validation and manufacturing engineering, order fulfilment management, order fulfilment realisation and post-order process. MacCarthy et al. (2003) then went on to identify fundamental operational modes for MC as illustrated in Figure 6.1.

Figure 6.1 Five fundamental modes of mass customisation

(McCarthy et al., 2003:298)
Chapter 6 Stage One – Findings of Exploratory study

The nature of this part of the study was exploratory and was conducted through a qualitative approach. To ensure validity of the findings, data was collected from three alternative sources (data triangulation). The first source of data was from a recently published textbook (Jones, 2004), and trade publications. The second source of data derived from observational studies of six flight kitchens in the United Kingdom (UK). Lastly, through structured interviews with managers in the flight catering industry, the third source of data was obtained. The next section described current flight catering operations gathered from observations, as well as questionnaires to managers from different flight catering companies.

6.2 Trends in flight catering operations gathered from interviews

The preliminary fieldwork began with unstructured observations based on visits to six flight catering companies in the UK. From initial observations, a grasp on the general idea of the operation processes in the flight catering industry was achieved. This enabled questions in relation to the MC processes proposed by MacCarthy et al. (2003), to be set. The fieldwork then went on to conduct structured interviews with eleven senior managers from international flight catering companies at the International Travel Catering Association (ITCA) trade show held in Nice, France (2004). ITCA is the largest organiser of flight catering events and trade shows in Europe, that were attended by well over 1000 delegates from catering companies, suppliers and airline companies annually.

Although all the catering companies surveyed were located in different parts of the world (Asia, Middle East and Italy), they all implied there was a commonality in this industry. First, all the companies showed that they have to cope with large volume of daily meal production (3000 - 8000 per day). At the same time, they all had to serve
several airline companies per day (20-30 flights daily). Hence, they possessed the same characteristics of having to cope with high volume and high variety. The respondents interviewed were senior managers with over 12 years of experience in their respective companies (see Appendix 5). As such, they had sound knowledge of the operation processes in the flight catering industry. The data gathered via the interviews was interpreted in relation to the operational processes of the flight catering industry by content analysis (see Appendices 6 to 9).

Starting with the menu design process, caterers would present airline companies with a list of different food items for them to pick and/or mix, to form menus they desired. To meet the ever changing needs of passengers, items in menus had to change constantly to provide passengers with a wide range of choices. All the caterers employed the services of professionals (chefs and nutritionists) or even a dedicated team to handle the design of new menus or products at the request of airline companies. Most caterers suggested that the typical lead time from design to production of a new menu or product, took about 1-2 weeks. Whenever a new menu or product was created, caterers invited airline companies and some invited passengers as well to test the new product. Feedback from airline companies and passengers was noted, and then modifications were made to meet customers’ requirements.

At the process engineering stage, a certain set of manufacturing procedures and rules had to be enforced to ensure that the same product could be manufactured again and again. In a typical manufacturing environment, bills of materials were generated along with guidelines on routing and processing instructions. Regarding the generation of bills of materials, the commonly used method to estimate the amount of food/ingredients necessary to provide enough meals for a flight, was calculated by multiplying the weight
of ingredients with passenger counts. Some had computer assisted systems and one relied on the size of aircrafts to estimate the amount. Once the amount of raw materials to provide for a certain flight was known, the next step was to assemble the different food items, for examples, salads, biscuits, butter and so on, onto the tray. This process was facilitated with the use of conveyor belts or workstations. In economy class (E/C), the variety of meals to choose from was very limited; and had to be served in large volumes. Therefore, conveyor belts were used for the production of economy class meals in large volumes.

As for first and business classes, workstations were utilised exclusively to produce tray sets for passengers. All the above mentioned measures could confirm the manufacturability of product design and establish a set of manufacturing processes and rules. If passengers could pre-order their meals at the same time when they booked their tickets and airline companies inform caterers in advance, many caterers would be able to customise the tray set for each passenger. This would promote flexible services to passengers and reduce any wastage.

Regarding the forecast of the number of tray sets to prepare for each flight, some companies replied that they preloaded the meals 24 hours before departure; and a final load was performed 4-6 hours before flight departure. Some had accounted 10% more on top of their estimated tray sets by their reservation systems informed by airline companies.

Business and first class meals were made in-house with the exception of economy class or some special meals, which were outsourced. To ensure correct dispatch of meals to passengers and to assure food safety procedures and systems such as Hazard Analysis
and Critical Control Point (HACCP) system and ISO9001 standard were in place. Besides HACCP, some companies adopted the ISO9001 standard. ISO9001 is a standardisation process that can help both product and service oriented organisations achieve standards of quality that are recognised and respected throughout the world.

Before meals could be served, there must be enough galley equipment to set up trays for passengers on board. Methods like Push System Running (PSR), Material Handling System (MHS) and warehouse inventory stock check ensured that caterers provide enough galley equipment to set up trays for passengers. Push system running is a systematic method of scheduling work based on demand so that the output is controlled without any excess or shortfalls. Material Handling Systems ensure efficient movement of materials throughout various processes like production, assembly, delivery and so on.

All companies suggested they followed a standard operational management protocol to control their processes, so that meals are delivered on time. HACCP as mentioned earlier, was one of the two operational standards companies employed to control the processes needed to operate or assemble meal sets for delivery to flights on time. Other companies applied JIT in their flight catering operations. JIT is an operational strategy that enforces the reception of materials JIT for the next manufacturing process.

In addition, all the caterers interviewed had strategies to manage flight delays. Sometimes flight delays were due to air traffic congestion and bad judgment from assembly workers which then led to error in predicting the provision of correct amount of food onboard. Some had buffer meals to curb with the shortfall in meal sets. One caterer suggested setting 2 hours of cold holding time before loading meals to keep the food fresh. Investigations of flight delay issues were immediately followed up and
rectified. Managing flight delays such as the use of buffer meals to make up the necessary amount, suggested that the companies were flexible in their allocation of resources in the event of flight delays.

6.3 The MC mode of the Flight Catering Industry

Prior to the conclusion of findings from the questionnaires surveyed, there was a need to recap and explain from what had already been discussed in Chapter 3 (section 3.10); that is, how the operational processes in an MC system can vary that resulted into five fundamental MC modes. MacCarthy et al. (2003) suggested that the operational processes can be classified as either per product/pre order, per order, pre order, post order and whether the order fulfilment process is fixed or modifiable. From MacCarthy et al.'s (2003) definition, per order means that the customer is involved at each order fulfilment cycle. In other words, the customer's product is designed and engineered between order taking and delivery. Per product relationship is where design and validation take place at the prompting of the customer, but prior to (repeat) orders being placed by the customer for that product. Pre order means that customers can order from a pre-specified range of products. On the other hand, post order means that the activities follow the completion of an order which include maintenance, warranty claims and technical guidance.

The difference between fixed and modified order fulfilment resource is that; they can fulfil within their present materials supply, processing and delivery resources, or they can modify them. Investing in additional or different process technology or engaging a new supplier or subcontractor; so as to enable the manufacture of customised products, all belonged to modified scope. Once-only and call-off differ in, if they can accept a customisation commission under repeat orders.
By analysing the responses to the questionnaire, temporal relationships of the flight catering industry were summarised. The process of order taking/coordination required the involvement of airline companies to understand their specifications. Therefore, this process was on a per order basis.

Caterers would provide a range of food items for airline companies to choose and form their desired menus. However, if airline companies desired special menus that could not be realised from the pre-fabricated list of food items, a dedicated team comprised of nutritionists and chefs, would handle such requests. As such, the process of design and development of menus was classified as per product/pre order, since caterers could provide a wide range of specific food items for airline companies to choose from or design their own menus. At the same time, menus could be repeated at the request of airline companies. In the process of product validation, testing of menus arose at the request of airline companies. Therefore, the process of product validation was by per product, where product validation was at the prompting of the customer.

With regard to the product validation and manufacturing engineering process, flight catering companies had computer assisted systems and a set of manufacturing rules and procedures to ensure the manufacturability of product designs. Assembly of materials required for production of meals was completed before customers’ orders were placed. Hence, tray service was classified to operate on a per product basis. In addition, meals could be repeated to meet the customers’ demands. Thus, the *product development/design and product validation and manufacturing engineering* of flight catering industries fulfilled requirements of flexible resource call-off because both operations took place prior to a request by airline companies.
Chapter 6 Stage One – Findings of Exploratory study

The order fulfilment management involved the airline companies throughout the process, since airline companies would provide caterers with the forecasted meals to supply. The final number of meals would be informed via teletext to caterers, four to six hours before flight departure. Hence, the order fulfilment management was classified as per order.

As mentioned in the previous section, evidences such as outsourcing of products (special meals), flexible allocation in resources (buffer meals in the event of flight delays) and delivery modes (special meals were separated from normal meals) showed that the order fulfilment realisation was modifiable.

With regard to post order process, caterers had customer relation departments to handle post order complaints by airline companies. In-depth investigations of food poisoning incidents would be carried out and replies would be sent promptly to the airline companies. From MacCarthy et al.'s (2003) five operational modes of mass customisation, modes D and E are very similar in every aspect, with the exception of order fulfilment realisation; where it is modifiable in mode E while fixed in mode D. Therefore, through the interpretation of the findings just conducted, the flight catering industry was categorised under mode E: flexible resource call-off mass customisation. Table 6.1 concludes the findings, along with the identified MC mode of the flight catering industry – Mode E.
Table 6.1 Classification of mass customisation mode for the flight catering industry

<table>
<thead>
<tr>
<th>Basic Processes</th>
<th>Mode E</th>
<th>Flight Catering Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order taking/co-ordination</td>
<td>Per order</td>
<td>On a per flight basis</td>
</tr>
<tr>
<td>Product development and design</td>
<td>Per product/pre order</td>
<td>Dishes and tray set-ups designed prior to contract/orders</td>
</tr>
<tr>
<td>Product validation and manufacturing engineering</td>
<td>Per product/pre order</td>
<td>Production layout &amp; assembly routines engineered prior to contract</td>
</tr>
<tr>
<td>Order fulfillment management</td>
<td>Per order</td>
<td>On a per flight basis</td>
</tr>
<tr>
<td>Order fulfillment realisation</td>
<td>Modifiable</td>
<td>Adjusted to reflect passenger numbers, flight delays, special meals, etc.</td>
</tr>
<tr>
<td>Post order processes</td>
<td>Post order</td>
<td>On a per flight basis</td>
</tr>
</tbody>
</table>

(Adapted from MacCarthy et al., 2003:299)

6.4 Conclusions

The flight catering industry was found to constantly deal with high volume and variety issues. Everyday, caterers not only had to supply the high volume of meals, but also required to serve different airlines. As such, the need to cope with volume and variety resulted in compromising the performances of catering companies. The concept of mass customisation allows high volume and high variety to be achieved, while no trade offs are necessary. Mass customisation may be the answer to flight catering industry for effective and efficient operations. Hence, the exploratory study in this chapter was set to understand current flight catering operations, in relation to processes in the five MC operational modes proposed by MacCarthy et al. (2003); to enable the identification of the MC mode for the flight catering industry.

From the analysis of the data collected, the flight catering industry fulfilled the requirement of flexible resource call-off. This was because production and assembly of
meals were completed before customers’ orders were placed, and the meals could be repeated on requests. There was evidence of flexibility in the allocation of resources, such as the allocation of buffer meals in the event of flight delays. In addition, the delivery modes were flexible; where special meals were separated from normal meals to ensure correct dispatch to the right passenger. Therefore, the *order fulfilment realisation* of the flight catering industry was classified as modifiable. Detailed examination of other processes, suggested that the *product development/ design and product validation/ manufacturing engineering* were on a per product/pre order basis. This meant that menu designs and validations were conducted at the prompt of customers, but prior to orders being placed. Since airline companies provisioned the forecasted amount of meals to the caterers, they were involved throughout the *order fulfilment management* process. As such, the *order fulfilment management* is on per order basis. From the interpretations just discussed, the flight catering industry was identified as Mode E – flexible resource call-off mass customisation. The findings of this exploratory study have been presented at the EuroCHRIE conference in October 2005 in Paris, France (see Appendix 10).
Chapter 7 Main Study – Phase I Data Envelopment Analysis Findings

7.1 Introduction
In the main study, performances of flight catering units were assessed, in order to identify efficient and inefficient units for further in-depth case study investigations to understand the effects of MC elements on operational efficiency. Data Envelopment Analysis (DEA) was employed to analyse the efficiencies and differences between efficient and inefficient flight catering units. Unlike other statistical methods, DEA is a non-parametric tool that does not need prior knowledge of the functional form and can accommodate multiple factors. The true efficiency of the flight catering business is complex and multidimensional, whereby a myriad of factors have to be taken into consideration. However, to date, there are no published articles related to the efficiency of the flight catering business and therefore, the functional form of the production frontier of this industry is still unknown. Evidently, DEA serves as an ideal tool to compute and examine the efficiencies of flight catering units due to its inherent non-parametric nature and ability to take into account multiple factors.

This chapter describes the data collection process for DEA analysis and reports the findings on the computed efficiencies of flight catering units.

7.2 Limitation of the data collection process
The data source for the collection of data was from Momberger world directory of flight kitchens released in autumn 2004. As a private survey company, Momberger gathered and lists information of numerous flight kitchens throughout the world. In total, the Momberger database has a comprehensive listing of 729 international flight kitchens. However, only 413 flight kitchens have email contacts and 421 flight kitchens have fax
contact numbers. In order to increase the response rate, the flight kitchens were contacted by both email and fax to obtain the required variables for DEA analysis. The requested 12 variables are listed in Table 7.1.

Table 7.1 Requested input and output variables through fax and email

<table>
<thead>
<tr>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
</tr>
<tr>
<td>(1) Total number of full time employees</td>
</tr>
<tr>
<td>(2) Number of full time employees in food production</td>
</tr>
<tr>
<td>(3) Total labour hours</td>
</tr>
<tr>
<td>(4) Total labour hours for setting up tray</td>
</tr>
<tr>
<td>(5) Total labour hours for hot food production</td>
</tr>
<tr>
<td>(6) Size of production unit</td>
</tr>
<tr>
<td>Outputs</td>
</tr>
<tr>
<td>(1) Number of different airlines served</td>
</tr>
<tr>
<td>(2) Number of first and business class meals</td>
</tr>
<tr>
<td>(3) Number of charter airline meals</td>
</tr>
<tr>
<td>(4) Average number of flights served</td>
</tr>
<tr>
<td>(5) Total number of tray sets</td>
</tr>
<tr>
<td>(6) Total number of hot meals</td>
</tr>
</tbody>
</table>

The first response was received 2 weeks later and other flight kitchens that had not responded yet (see Appendix 11), were contacted again by email or fax again as a first follow-up (see Appendix 12). Gradually, more responses were received but unfortunately, only 23 flight kitchens replied, where 19 of them had provided complete usable data. The remaining 4 kitchens with 2 missing variables were approached again by email to request for the missing variables but they declined to divulge any further information for those variables. As mentioned in section 5.9.5 of Chapter 5, the sampling size has to be sufficiently large for proper discrimination by DEA. A small sampling size will obscure and bias the efficiency scores. Dyson et al. (1990) and Sigala et al. (2005) all suggested that the sampling size should be significantly greater than \((N \times M)\), where \(N\) is the number of inputs and \(M\) is the number of outputs. Therefore, in order to obtain rational DEA results for the desired 12 variables requested, the number of samples should be substantially greater than 36 \((6 \times 6)\). However, only 19 samples with complete data were available, which is only about half of the required sampling.
size for accurate DEA results. Therefore the insufficient samples resulted in improper DEA discrimination (see Appendix 13).

An alternative solution to the sampling problem was sought after from the Momberger data source itself. With 861 international flight kitchens listed the Momberger database represented the total population of large flight kitchens, but only information on 5 variables were available (see Table 7.2 for the listed 5 variables).

<table>
<thead>
<tr>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
</tr>
<tr>
<td>(1) Total number of full time employees (2) Building size</td>
</tr>
<tr>
<td>Outputs</td>
</tr>
<tr>
<td>(1) Number of meal trays produced (2) Number of airlines served (3) Average number of flights per week</td>
</tr>
</tbody>
</table>

Of the 729 flight kitchens in the Momberger database, some kitchens had null values in either of their variables, which could render the DEA results inaccurate. In total, there are 134 kitchens with complete usable data. In this case, the problem of insufficient sampling size was resolved but at the expense of a smaller number of variables that represent the general production model of the flight kitchens. Inevitably, the sample size required and the number of variables formed a limitation for this study. However, since the intention of the DEA analysis is to identify efficient and inefficient flight catering units for further in-depth case studies, the issue of finding a production model for the flight catering business is not essential in this context.
7.3 Stepwise approach to DEA

As mentioned in Chapter 5, the inclusion of any irrelevant inputs or outputs into the DEA model will influence and bias the efficiency score. In knowledge of the implication involved, an approach known as the stepwise DEA method was implemented in this study (refer to section 5.9.3 of Chapter 5).

For the DEA analysis in this study, the 5 variables obtained from the Momberger database were assessed using the stepwise approach to identify inputs and outputs that are significant to efficiency contribution. In the first stage, a single input and output had to be selected to form a basic DEA model. From Table 7.2 in the previous section, the more obvious input and output that have impact on flight catering efficiency are ‘total number of full time employees’ and ‘number of meal trays produced’, respectively. The rationale behind the selection of these two variables was simply due to the fact that the efficiency of a flight catering operation has a direct relationship with the number of meal trays produced and the number of workers in the unit. With the basic model identified, the efficiencies of the flight catering units were computed by DEA and are shown in Table 7.3.

<table>
<thead>
<tr>
<th>Unit name</th>
<th>DEA Efficiency Score (%)</th>
<th>Unit name</th>
<th>DEA Efficiency Score (%)</th>
</tr>
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<td>1 LHRHS-London south UK</td>
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<td>Lima Peru</td>
<td>0.55</td>
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</table>

Then, a Pearson correlation test was employed to examine the relationship between the efficiency scores and the remaining 3 variables. Based on a linear concept, the Pearson correlation requires the variables to fulfill an important criteria: all the variables must be normally distributed. A P-P plot is used to observe the normality of the variables and is basically a graph showing the deviation of data from an ideal diagonal regression line. If all the data of the variable falls in a straight line along the ideal diagonal line, then that variable is said to be perfectly normally distributed. Figure 7.1 shows the P-P plots for the computed DEA scores in the first stage and the remaining 3 variables.
Figure 7.1 P-P plots to examine the normality of efficiency scores from first stage of stepwise DEA and remaining variables (building size, average flights per week and number of airlines served).

Evidently from Figure 7.1, all the variables were not normally distributed because of the wide deviation from the ideal diagonal regression line. In order to apply Pearson correlation, the variables were logarithmic transformed to obtain the linearity required. Figure 7.2 shows the P-P plots of the transformed variables.
Figure 7.2 P-P plots of logarithmic transformed variables

The plots in figure 7.2 show that the transformed variables were quite close to the ideal diagonal line and therefore, could be deemed normally distributed. At this stage, the variables are now suitable for the Pearson correlation test. Table 7.4 displays the correlation results.
Table 7.4 Correlation between efficiency scores computed from first stage of stepwise DEA and remaining variables

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<th>logBuildingsize</th>
<th>logAverageflights</th>
<th>logno.airlines</th>
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<td>-.294**</td>
<td>-.168*</td>
<td>-.132</td>
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<td><strong>Sig. (2-tailed)</strong></td>
<td>.001</td>
<td>.050</td>
<td>.126</td>
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<tr>
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<td>136</td>
<td>136</td>
<td>136</td>
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<tr>
<td><strong>Correlation</strong></td>
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<td>1</td>
<td>.632**</td>
<td>.340**</td>
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<tr>
<td><strong>Sig. (2-tailed)</strong></td>
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<td>.000</td>
<td>.000</td>
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<td>136</td>
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<tr>
<td><strong>Correlation</strong></td>
<td>-.168*</td>
<td>.632**</td>
<td>1</td>
<td>.248**</td>
</tr>
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<td><strong>Sig. (2-tailed)</strong></td>
<td>.050</td>
<td>.000</td>
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<td><strong>Correlation</strong></td>
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<td>.340**</td>
<td>.248**</td>
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<td><strong>Sig. (2-tailed)</strong></td>
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</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

As seen in Table 7.4, all the remaining variables were found to be correlated with the computed efficiency score after the first stage of stepwise DEA. The highest correlated variable was ‘building size’ which had a correlation value of 0.294. Hence, the variable ‘building size’ was included into the DEA model for the next stage of stepwise DEA. With the new variable added, the efficiencies were computed again and the efficiency scores are shown in Table 7.5.

Table 7.5 Efficiency scores computed from second stage of stepwise DEA

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<th>Efficiency Score (%)</th>
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Chapter 7 Main Study – Phase I Data Envelopment Analysis Findings
Chapter 7 Main Study – Phase I Data Envelopment Analysis Findings

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Again, a Pearson correlation test was conducted for the 2 remaining transformed variables and the transformed computed efficiency scores from the second stage of stepwise DEA. The correlated results are display in Table 7.6.
Table 7.6 Correlation between efficiency scores computed from second stage of stepwise DEA and remaining 2 variables

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**• Correlation is significant at the 0.01 level (2-tailed).

Of the 2 remaining variables, the variable ‘average number of flights per week’ was found to be negatively correlated with the computed efficiency scores from the second stage of stepwise DEA. In contrast, the variable ‘number of airlines’ had a correlation value of close to zero and was therefore not considered correlated with the efficiency scores. However, this variable was not to be dismissed at this point until the final stage of stepwise DEA was performed. With the variable ‘average number of flights per week’ added to the DEA model, efficiencies of the flight kitchens were computed again and the results were displayed in Table 7.7. At this point, there remained only 1 variable which was to be determined by the final stage of stepwise DEA if it was to be included into the model. Table 7.8 shows the correlation results between the computed efficiency scores from the third stage of stepwise DEA and the remaining variable.
### Table 7.7 Efficiency scores computed from third stage of stepwise DEA

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### Chapter 7 Main Study – Phase 1 Data Envelopment Analysis Findings

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Table 7.8 Correlation between efficiency scores computed from third stage of stepwise DEA and the remaining variable

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<th>logDEAscore Sig. (2-tailed)</th>
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**. Correlation is significant at the 0.01 level (2-tailed).

A negative correlation of 0.24 was observed between the efficiency scores computed from the third stage of stepwise DEA and the remaining variable. This implied that the variable had to be included into the DEA model. The stepwise DEA analysis concluded that all 5 variables from the Momberger database were significant to efficiency contribution. A robust DEA model was thus created that contained all relevant variables which would now give accurate DEA results.

7.4 DEA findings

With all relevant inputs and outputs considered in the DEA model, efficiencies of 134 flight kitchens from the Momberger database were analysed and the findings are summarised in Table 7.9. The computed efficiency scores by DEA showed that only 9 flight kitchens out of 134 kitchens are efficient (100% score). From the distribution of efficiency scores in figure 7.3, 60.3 % (82 kitchens) of the flight kitchens were in the range of only 11% - 40% efficient. Thus, majority of current flight kitchens were very inefficient compared to kitchens that adopt the best practice or strategy. In fact, figure 7.4 revealed that the 3 major dimensions in the inefficient flight kitchens that could potentially be further improved on were, ‘no. of airlines served’ (39.5 %), ‘total no. of employees’ (29 %) and ‘building size’ (29.5 %).
With the efficient and inefficient flight kitchens identified, the study was able to select efficient and inefficient flight kitchens for case studies. The original intention was to select the two efficient and two inefficient flight kitchens. However, taking into
consideration the costs and time taken to interview a kitchen that is far away from UK, only European flight kitchens close to the UK are considered. The selection process for case study investigations started from the top of the table and sequentially down the table to select two efficient kitchens close to the UK. Erfurt Germany flight kitchen (Unit No. 1) was first contacted but refused to be interviewed. Eventually down the table Flight Catering Company C and Flight Catering Company D which were also 100% efficient, accepted to be interviewed. Similarly, the two inefficient flight kitchens were selected from the bottom of the table and sequentially moving up until two kitchens close to the UK were identified. These kitchens were then contacted and the two kitchens accepted to be interviewed were Flight Catering Company A and Flight Catering B.

Table 7.9 DEA efficiency scores under the CCR model

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<td>59.75</td>
<td>87</td>
<td>Atlanta 300 USA</td>
<td>21.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Buenos Aires - AEP Argentinian</td>
<td>59.44</td>
<td>88</td>
<td>Singapore changi</td>
<td>20.99</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>West Palm Beach 427 USA</td>
<td>56.7</td>
<td>89</td>
<td>Copenhagen Denmark</td>
<td>20.54</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Dallas / Ft Worth 800 USA</td>
<td>55.02</td>
<td>90</td>
<td>Baku Azerbaijan</td>
<td>20.44</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Malaga Spain</td>
<td>54.3</td>
<td>91</td>
<td>San Francisco 249 USA</td>
<td>20.13</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trabzon Turkey</td>
<td>53.99</td>
<td>92</td>
<td>Munich Germany</td>
<td>20.1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>London Stansted UK</td>
<td>53.08</td>
<td>93</td>
<td>Mexico City Mexico</td>
<td>19.72</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Phoenix 735 USA</td>
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<td>94</td>
<td>Caracas Venezuela</td>
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</tr>
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<td>9</td>
<td>Atlanta 302 USA</td>
<td>50.1</td>
<td>95</td>
<td>Roca Puerto Plata Dominican</td>
<td>19.01</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Chicago 240 USA</td>
<td>49.94</td>
<td>96</td>
<td>Malpensa Italy</td>
<td>18.86</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Hamburg Germany</td>
<td>49.81</td>
<td>97</td>
<td>Bucharest Romania</td>
<td>18.52</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Bergen Norway</td>
<td>49.52</td>
<td>98</td>
<td>China Pacific Catering</td>
<td>18.29</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Philadelphia 108 USA</td>
<td>48.15</td>
<td>99</td>
<td>Los Angeles 237 (574) USA</td>
<td>17.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Roca Santo Domingo</td>
<td>17.84</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Muscat Oman</td>
<td>47.09</td>
<td></td>
<td>Dominican</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Orlando 566 USA</td>
<td>46.72</td>
<td>101</td>
<td>London Heathrow Feltham UK</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Toronto Canada</td>
<td>45.2</td>
<td>102</td>
<td>Jeddah Kingdom of Saudi Arabi</td>
<td>17.48</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Beijing China</td>
<td>44.82</td>
<td>103</td>
<td>Kuala Lumpur Sepang Malaysia</td>
<td>16.32</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Portland 234 USA</td>
<td>43.98</td>
<td>105</td>
<td>Bahrain State of Bahrain</td>
<td>16.31</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Funchal Portugal</td>
<td>43.4</td>
<td>106</td>
<td>Malpensa Italy</td>
<td>15.86</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Recife Brazil</td>
<td>42.92</td>
<td>107</td>
<td>Zurich Switzerland</td>
<td>15.05</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Male Republic of Maldives</td>
<td>41.88</td>
<td>108</td>
<td>Stockholm Dusseldorf Germany</td>
<td>14.91</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Tampa 725 USA</td>
<td>41.42</td>
<td>109</td>
<td>Nogoya Japan</td>
<td>14.61</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Stockholm Munster-Osnabruck G</td>
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<td>110</td>
<td>Sao Paulo Brazil</td>
<td>14.59</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Hannover Germany</td>
<td>39.59</td>
<td>111</td>
<td>Xian China</td>
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</tr>
<tr>
<td>25</td>
<td>Munich Germany</td>
<td>38.45</td>
<td>112</td>
<td>Honolulu 244 USA</td>
<td>14.29</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Lodon Gatwick Unit2 UK</td>
<td>38.41</td>
<td>113</td>
<td>LHRHS-London south UK</td>
<td>14.19</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Chicago 241 USA</td>
<td>37.59</td>
<td>114</td>
<td>Warsaw Poland</td>
<td>14.17</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Bodrum / Milas Turkey</td>
<td>37.57</td>
<td>115</td>
<td>Quito Ecuador</td>
<td>14.16</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Las Vegas 711 USA</td>
<td>37.51</td>
<td>116</td>
<td>JFK NY 740 USA</td>
<td>13.65</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>London Heathrow North Feltham</td>
<td>37.38</td>
<td>117</td>
<td>Sharjah USA</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>St. Louis / Basel France</td>
<td>36.94</td>
<td>118</td>
<td>Miami 444 (447) USA</td>
<td>13.32</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Berlin Schonefeld Germany</td>
<td>36.29</td>
<td>119</td>
<td>Guayaquil Ecuador</td>
<td>13.14</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Atlanta 301 USA</td>
<td>35.44</td>
<td>120</td>
<td>Frankfurt Germany</td>
<td>12.58</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Leipzig/ Halle Germany</td>
<td>35.37</td>
<td>121</td>
<td>Hangzhou China</td>
<td>12.25</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Augsburg Germany</td>
<td>34.95</td>
<td>122</td>
<td>Saipan Micronesia/Northern Mar</td>
<td>12.16</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Augsburg west Germany</td>
<td>34.92</td>
<td>123</td>
<td>Madrid Spain</td>
<td>12.05</td>
<td></td>
</tr>
</tbody>
</table>

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7.5 **Characteristics of the selected flight catering unit as case studies**

In this section, characteristics of the selected four flight catering companies in the previous section were described. Flight Catering Company C and Flight Catering Company D consisted of a workforce smaller than 50 employees in each unit, and the physical building size of each unit was smaller than 1500 m². In comparison, Flight Catering Company A and Flight Catering Company B had a workforce greater than 140 employees in each unit, and the physical building size of each unit was greater than 3000 m².

7.6 **Conclusion**

In order to analyse the efficiencies of flight catering units for the selection of case studies, Data Envelopment Analysis (DEA) was employed. To date, the production frontier of the flight catering industry is not published in any articles and therefore, there is no prior knowledge of its functional form. Based on a non-parametric methodology, DEA does not require knowledge of the functional form of the production frontier and can accommodate multiple factors. Hence, DEA is an ideal tool.
for the assessment of operational efficiency of the flight catering business. There was another important reason why DEA was employed to investigate the efficiencies of flight catering units. DEA is closely related to the methodology of the 'Theory of Performance Frontiers' described by Schmenner and Swink (1998) (see section 2.3.3 in Chapter 2). Under this theory, the adoption of MC strategies and policies in flight catering units would suggest a shift in their operating frontiers. DEA established an efficient frontier where all inefficient units referenced to; and if MC strategies and practices were correctly adopted in the inefficient units, their operating frontiers would shift to the efficient frontier.

The data source for DEA analysis was from the Momberger world directory of flight kitchens with a listing of 729 international flight kitchens. Flight kitchens were contacted to obtain the desired 12 variables by email and fax which were listed in the Momberger database. However, only 23 kitchens responded and only 19 kitchens had complete usable data. In knowledge of the fact that a small sampling size will render the DEA results inaccurate, an alternative method to obtain more samples was sought after. Data were then collected from the 729 flight kitchens in the Momberger database, but only 5 variables were available. Out of the 729 samples, 134 samples had complete data and were analysed by DEA. In total, 9 flight kitchens were found to be efficient (100%). Two efficient and two inefficient kitchens were selected from this range and contacted for case study investigations.
8.1 Introduction

Based on the first stage results obtained from Data Envelopment Analysis presented in Chapter 7, the identification of efficient and inefficient flight catering companies allowed the selection of units for further in-depth evaluations. A case study approach was used to study four flight catering companies which consisted of two efficient and two inefficient units. The intention of this chapter was to report the findings from the conducted field case studies. Data were collected through field visits, interviews, observations, audits and documentations from all four case companies. The face to face interviews were captured with the assistance of an interview protocol to guide the discussion towards the determination of the types of MC elements in their operational processes. With the aid of a digital recorder, the raw data from the interviews were transcribed into verbatim transcript; with all references to the catering company's name deleted to ensure confidentiality. Consequentially, in order to differentiate between the four companies, the two inefficient units were coded as Flight Catering Company A (FCCA) and Flight Catering Company B (FCCB); while the other two efficient units were named as Flight Catering Company C (FCCC) and as Flight Catering Company D (FCCD) (see Appendix 16 for each individual case study report). The narrative description of the four companies in the sections that follow, explored the processes in the flight catering operations.

8.2 Company background

In order to further enhance the understanding of operational processes in the flight catering industry, two efficient and two inefficient units were selected by Data
Envelopment Analysis as case studies. Flight Catering Company A and B are subsidiaries of the same larger operating group that provides airport retail services, flight catering services and airport catering services (restaurants and bars in airports). The group has operations in 8 countries that spanned across 4 continents: UK, Continental Europe, USA, Middle East and Australia. Of interest, the flight catering operation of the group has 32 flight kitchens at 27 airports in the UK, as well as kitchens in Amsterdam and Orlando, USA.

Flight Catering Company A is situated 7 miles away from Schiphol international airport in Holland and served a total of 13 long and short haul airlines. Currently, the unit has a total workforce of 141 staff. The unit occupied a floor space of 8000 m² and claimed to have the capability in excess of producing 41,000 meals per week for the increased number of meals during peak seasons.

Flight Catering Company B, on the other hand, is situated just 1 mile away from Birmingham international airport in UK. The unit served a total of 23 airlines, of which two are long haul airlines and the rest comprised of both charter and short haul airlines. The current workforce of Catering Company B is 186 staff. Occupying two floor spaces of 3335 m², the unit claimed to have the capability in excess of producing 80,000 meals per week for the increased number of holiday makers during peak seasons.

Flight Catering Company C and D are subsidiaries of the same larger group that operates gastronomic outlets at airports, railway stations, fairs and event houses in Germany. The air catering operation of the group had over 30 years of experience in the airline catering market.
Flight Catering Company C is located 500 metres away from Köln/Bonn international airport in Germany and provides catering services to a total of 11 airlines, which consisted of charter and schedule flights. In total, the unit has a workforce of 48 staff. Built in the year 2000, the two storeys 1433 m² unit that occupied a floor space of 1433 m², was originally designed for the capacity of producing 7000 meals per day. However, during seasonal peak periods, the unit claimed to have the capacity in excess of producing 11,900 meals per week.

Flight Catering Company D served a total of 13 airlines which consisted of all charter and occasional VIP flights. Located 2 miles away from Leipzig/Halle international airport in Germany, the unit has a workforce of 28 staff. The unit was recently built in the year 2002, which occupied two floor spaces of 709 m². Originally, the capacity of the unit was designed to produce 7000 meals per day, but they claimed they could produce in excess of 17,500 meals per week for the increased number of holiday makers during peak seasons. A summary of general information for each unit is shown in Table 8.1.
Table 8.1 Summarised the general information about each unit

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Total number of tray sets/per week</td>
<td>41000</td>
<td>69700</td>
<td>11900</td>
<td>17500</td>
</tr>
<tr>
<td>2 Total number of hot meal produced/per week</td>
<td>28695</td>
<td>2613</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 Number of chatter flight meals/per week</td>
<td>0</td>
<td>2682</td>
<td>80% chatter flights</td>
<td>All chatter flights</td>
</tr>
<tr>
<td>4 Number of first and business class meals/per week</td>
<td>4216</td>
<td>2435</td>
<td>350</td>
<td>120</td>
</tr>
<tr>
<td>5 Average number of flights served</td>
<td>81</td>
<td>499(359)</td>
<td>165</td>
<td>45</td>
</tr>
<tr>
<td>6 Number of airlines served</td>
<td>13</td>
<td>23 (long haul 2)</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>7 Total number of full time employee in the units</td>
<td>141</td>
<td>186</td>
<td>48</td>
<td>28</td>
</tr>
<tr>
<td>8 Number of full time employees in food production</td>
<td>38</td>
<td>35</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>9 Building size m²)</td>
<td>8000</td>
<td>3335</td>
<td>1433</td>
<td>706</td>
</tr>
<tr>
<td>10 Number of Suppliers</td>
<td>35</td>
<td>52</td>
<td>10 and 30 duty free</td>
<td>7 and 12 duty free</td>
</tr>
<tr>
<td>11 Dish packing assembly methods</td>
<td>Table top B/C, E/C</td>
<td>Table top E/C, B/C</td>
<td>Table top E/C, B/C</td>
<td>Table top E/C, B/C</td>
</tr>
<tr>
<td>12 Food assembly methods</td>
<td>Table top B/C, E/C</td>
<td>Table top E/C, B/C</td>
<td>Conveyor belt</td>
<td>Conveyor belt</td>
</tr>
<tr>
<td>13 Number of Shits assembly</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

8.3. Descriptive case study of operational processes

8.3.1 Two key performance indicators of management

In order to achieve targeted goals and standards set by the management, all four catering companies employed certain Key Performance Indicators (KPIs) for their respective departments to meet. Flight Catering Company A had three KPIs, namely, meals per hour for the hot food production, tray setups per hour for the assembly department and trays per hour for the washing department. As their internal manager explained:
... it's always 2 weeks of KPI planning in advance. Roughly, this KPI value is 10 completed meals in total per person per hour. For the E/C class, each staff has to achieve 55 tray setups per hour. In the washing area, it is 65 trays per person per hour.

Flight Catering Company B also had to work towards three KPIs, namely, meals per hour, cost per hour and meals per flight. Their process control manager further commented:

*A food related department works towards meals per hour KPI, while the workers who load meals onto the flights work towards hours per flight KPI. For instance, workers in the hot kitchen have to achieve 130 meals per hour of labour used. In cases where this KPI value is not achieved, the management would like to know why they are below that value. In addition, there are a number of other KPIs such as cost per hour and meals per flight. Therefore, on a day to day basis, we use KPIs to manage the business.*

For the smaller Flight Catering Company C and D, they set fewer KPI targets. Flight Catering Company C had two KPIs, namely, meals per hour and labour hours per day to fulfil. The unit manager explained the expected KPI targets in his unit:

*Workers in the kitchen have to achieve 1800 meals per day of labour used.*

*In our unit, we have 14 drivers and they work 20 days a month.*

*Theoretically, I should have 280 (14x20) man-hours. I expect the driver to*
do 3 loadings per day (3 x 280) 840 man hours. During the winter, the loading decreased down to 20 in January, I re-assign tasks for the drivers to make up the hours they are supposed to do. They will take a place in the wash area which does not require much skill.

Lastly, Flight Catering Company D only reported one KPI, which was the number of meals completed per hour. In general, workers in the hot kitchen had to achieve 2000 meals per day per person. Apart from KPIs which were set for the workers, both Flight Catering Company C and D assessed the performances of their managers too. As both units said:

*By looking at historical data, the computer system not only assists our company to set KPI targets within budget, but also assesses the performances of our managers. Any manager’s primary responsibility is to ensure that a good-quality product is produced before loading into the aircraft in a clean environment within company guidelines.*

### 8.3.2 Functional flexibility and temporal flexibility

Working hours in the various departments in all four units were based on schedules generated by the operation department. The operations department was the first point of contact that dealt with operation changes, live operations, off schedule flights, flight diversions and also received passenger figures on a daily basis. Hence, the operations department in each unit knew how many meals to produce each day, which enabled them to plan the work schedules for each respective department. For both Flight Catering Company A and B, first and business class food assembly was divided into 2
work shifts, while economy class food assembly was divided into 3 shifts. On the other hand, there were 2 shifts for the hot kitchen in order to produce high quality food by ensuring freshness rather than food items being pre-cooked and stored for a few days. Hence, all business class meals were cooked half-day in advance prior to flight departure. Similarly, food assembly and dish packing in Flight Catering Company C and D were divided into 2 work shifts. The work schedules for the washing department in Flight Catering Company C and D were quite different. For Flight Catering Company D, the washing department was divided into 2 work shifts. In comparison, work schedules for the washing department in Flight Catering Company C were divided into summer and winter programmes as shown in Table 8.2.

<table>
<thead>
<tr>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 days of 2 shifts, handled by 2 workers 06.00 – 15.00 and 14.00 – 22.00</td>
<td>7 days of 1 shift handled by 2 workers 10.00 – 19.00</td>
</tr>
<tr>
<td>4 days of 1 shift handled by 3 workers 10.00 – 19.00</td>
<td></td>
</tr>
<tr>
<td>4 days of 1 shift handled by 2 workers 10.00 – 19.00</td>
<td></td>
</tr>
</tbody>
</table>

As shown in the table, either more shifts or more workers were designated during the summer, to produce the increased number of meals for the holiday makers. In comparison, only 2 workers were designated to work on 1 shift during the winter period, where there were less travelling passengers.

*Temporal flexibility* was clearly exhibited in all four units. During seasonal peaks such as summer and Christmas holidays, the units recruited temporary employees to supplement a smaller core of full time employees, thereby increased the productivity to meet the rise in demand.
Functional flexibility was also evidently displayed in all four units. Flight Catering Company A and B said that their workers were shuffled daily to work on different roles. However, not all workers could be shuffled to take on the different tasks. For instance, chefs required a special technical skill, so they would not take any economy class worker and put them into the hot kitchen. As the internal manager of Flight Catering Company A explained:

We shuffle the different flight schedules daily for our workers and based on the same process they are in. For instance, F/C and B/C class workers require more skills, so E/C workers only can cover E/C assembly when there is a shortage of workforce but not F/C and B/C class related works. As I mentioned before, JAL (Japan Airline) is our largest customer and the tray setup is more complex than the other airlines, plus they are produced on the same day of flight departure. So, we sometimes need more staff to cover it especially when the flight is fully booked. This is when we shuffle our staff to cope with the shortage in manpower.

The food assembly manager of Flight Catering Company D further advocated:

The primary reason for shuffling flight schedule is to promote cross training of workers which then increases the operations flexibility. The swap of workers is normally within the same process. For instance, to cover shortage of workforce sometimes they will take tray assembly worker and maybe put them into cold assembly or despatch department.
Due to the relatively smaller workforce in smaller size Flight Catering Company C and D, the shuffling of workers was broadened to include drivers in other departments to supplement the shortage in manpower. For instance, in the event of any shortage in workforce, drivers from the despatch department would cover the workload of the stores area by receiving goods or the unskilled task of washing up in the washing department. In addition, sometimes they would take a tray assembly worker and put him/her to the cold assembly or despatch department to help out. The unit manager of Flight Catering Company C further commented on the cross functionality of his workers:

_During the winter, on or around the 28th of October, business is like dead._

*If there is not enough work for drivers during winter, they will do the washing up. If there is not enough work for cabin-packing workers, the drivers will do cabin packing. The workers who work in the cabin packing will go into the kitchen to do assembly if there is shortage of labour there._

_That's how I arrange the schedule for my employees._

The hiring of temporary workers by all the four units to supplement their workforce during peak seasons, as well as the designation of different tasks for their workers, especially for Flight Catering Company C and D; showed that they adopted the concept of flexibility as discussed back in Chapter 2, to cope with increasing demands. Within the four flight catering companies were some significant differences on the functional abilities of their workers. Workers in Flight Catering Company A and B were only shuffled to work on tasks within the same process. As such, their functional abilities were limited to within the
same process. In comparison, the drivers in Flight Catering Company C and D were designated to work on different tasks outside their main process.

8.3.3 Information technology implementation of material requirement planning

In any form of sustainable business, forecasting has become an important factor that helps a company to reduce costs by eliminating unnecessary waste and prevents overstocking. In a manufacturing environment, Material Requirement Planning (MRP) is used to forecast the necessary raw materials to meet a certain demand. All four flight catering companies were found to have implementations of computer systems to assist them in MRP realisation. In Flight Catering Company and B, this computer system was known as the Flight Catering Management System (FCMS). A different name for this computer system was used in Flight Catering Company C and D, which was known as the ‘X-Net’. Despite the difference in naming their computer systems, both served the same purpose in assisting the forecast process.

Orders were planned in advance, via MRP using FCMS/X-Net to eliminate unnecessary waste. The forecast process was divided into two steps. First, the prediction of the quantities required for certain ingredients, was achieved by stating the menu specification agreed with the airline company; which then allowed the requirement for raw materials and ingredients to be estimated. Within the menu specification, there were details containing meal description, menu rotation, product code, entrée and recipe. The standard recipe was an essential component in flight food production. As an example, a vegetarian entrée for Singapore Airlines, Asian Business class, comprised of: 140 g of Indian scramble egg, 40g of mushrooms and 1/2 potato. Hence, if a flight had 10 passengers, the unit then needed to place an order for 1400g (140g x 10) of
scramble egg and 400g (40g x 10) of mushrooms. Once the raw materials and ingredients for a specific menu was defined, the second step of the forecast process then involved inputting the estimated quantities of raw materials and ingredients into the computer system. The combination of flight schedule knowledge and recipe detail was the advanced information for input into the FCMS/X-Net to forecast and reduce inventory stock. For instance, actual passenger figures obtained from the operation department was fed into FCMS/X-Net and with the offered menu’s ingredients known, the quantities of ingredients could be forecasted and bought, which then prevented overstocking.

The implementation of MRP indicated that all the four flight catering companies used a Pull-system instead of a Push-system. In essence, a pull system is a method of controlling the flow of resources by replacing only what has been consumed. Traditional manufacturing plants use a push system where production schedules are developed for maximum capacity based on sales forecast pushing materials downstream. With MRP, the units were able to forecast the number of meals, equipment, raw materials and so on; in order to reduce any unnecessary meals that might have resulted from over-production, and the prevention of excessive storage of unnecessary equipment and raw materials. All these measures that the adoption of MRP had provided, advocated the concepts of lean production and JIT as mentioned in Chapter 2.
8.3.4 Operation department

In general, the work flow for all four flight catering companies first began with the operation department as mentioned in section 8.3.2 (a detailed work flow layout for each unit is provided in Appendix 16). The operations department generated figures pertaining to information that included the number of meals to be produced (crew, passenger and special meals) and flight schedules (estimated arrival and departure time). Hence, they know how many meals to produce for each day. Figure 8.2 shows the typical internal flight figures generated by the operation department, which allowed workers in the hot kitchen and food assembly to prepare for tomorrow’s flight schedules.
8.3.5 Goods inward

The second process in the work flow was the receipt of goods into the store. Due to the large number and diversity of airlines served, Flight Catering Company A and B had 35 suppliers and 52 suppliers respectively. In comparison, Flight Catering Company C and D served fewer airlines that were comprised mainly of charter and schedule flights, had only 10 suppliers and 7 suppliers respectively. Delivery of goods was continuous from morning till afternoon/evening with the exception of Flight Catering Company D, where delivery was only twice a day (8.00 am to 12.00 pm and 1 pm to 3 pm). The logistic supply manager of Flight Catering Company A said that delivery of goods was not on a daily basis, so they had to keep some stocks:

For the dry goods, depending on the supplier, in general we have between 7 to 10 days of stock because most of our suppliers come once a week. There are 1 or 2 suppliers which we have a minimum order for this amount of
pellets or boxes and we have to order every 2 or 3 weeks. So, for a particular item, the stock is a bit higher. For instance, these items are our ambient (ambient describes a product that you can store without chilling or frozen) sauces, base sauces (hot kitchens uses). So, normally, our suppliers come once a week. For some dry goods, some suppliers come every 2 weeks but that's just one or two. Food like raw meat comes in 3 to 4 times a week. They come in every Monday, Tuesday, Thursday and Friday. Fresh vegetables come in twice a day except on Sunday, because there is no delivery whatsoever on a Sunday, so that makes it more fresh, there will be no over production.

Goods received documents were passed to the stores team who then checked for all items arriving at the units. Apart from fulfilling the task of dispatching, the lorry driver in Flight Catering Company D was also assigned the task of receiving goods from suppliers. The inspection of items for the four units was facilitated by a report generated by FCMS/X-Net that had details on what the opening stock of each individual product was, how many they received in one month, what was the closing stock and what the items were actually used for. As the food supplier manager of Flight Catering Company B remarked:

*We have a report generated by FCMS that tells us basically what the opening stock of each individual product was, how many we received in one month, what the closing stock was and what we actually used. We use that report to obviously stop us losing money and then go forward.*
Besides the obvious check of product type and quantity, the stores team in all four units would also check for quality and for chilled items. In addition, temperature checks on food items were also conducted, especially for cheese and ham. Any items that failed to reach the agreed standards or were not within the correct temperature guidelines, were rejected and returned to the suppliers. The stores team then categorised the goods accordingly as dry items, wet items and frozen items. Dry items were obviously food items such as coffee bags and butter that could be stored for very long periods of time and not required to be frozen to keep fresh. Certain items were chilled in order to ensure freshness. These included items like yogurt, milk, fresh vegetables and fruits. Items with a relatively shorter lifespan like meat were frozen to keep them fresh. Figure 8.3 shows items in a typical store, and Table 8.3 summarised the number of different items in the four flight catering companies interviewed. Since Flight Catering Company A and B served more airlines and long haul flights, the number of items in their stores was in the orders of hundreds. In comparison, Flight Catering Company C and D served less airlines which were mainly charter flights, so the number of either dry or chill items was less than 50. Thus, Flight Catering Company A and B had more volume issue to deal with in their stores.

Figure 8.3 Items in store in Flight Catering Company B.
Apart from classifying different food items, the stores team of all four units also had to label items for the same flight schedule, so that other departments could identify easily when collecting them for processing. Different coloured stickers were used to assist staff in identifying which day the product was made. This classification not only enabled easier identification, but also facilitated the implementation of the 'first in first out' concept in all four units. Hence, based on this concept, if there were two same items but one arrived in store earlier than the other, the item with the longer storage period would be utilised first. In essence, the implementation of this concept allowed food items to be used within their expiry dates and in turn, reduced any waste that arose from expired food items. As the head chef and food assembly team manager of Flight Catering Company B explained:

*The fresh sandwiches outsourced from other manufacturers were attached with colour stickers in order to distinguish which day they were produced and for easy identification by our staff so that they know which items should be used based on the first in first out concept. Different colour stickers represent different days of the week for instance, blue is Friday, yellow is Saturday, Sunday is pink, white is Monday, Tuesday is red, Wednesday is brown and Thursday is green.*

The evidence of 'first in first out' implementation was another indication of methods used by all the four flight catering companies to reduce waste. Again, elimination of waste is the main objective of lean production.
Table 8.3 Summary of the number of dry and chilled items for each unit during the day of audit.

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry items</td>
<td>700</td>
<td>200</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Chilled items</td>
<td>200</td>
<td>600</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>Concept of goods utility</td>
<td>First in first out</td>
<td>First in first out</td>
<td>First in first out</td>
<td>First in first out</td>
</tr>
</tbody>
</table>

8.3.6 Food production

The next process in the work flow was food production, where workers from the food production department collected the food materials from the store for processing. All four units said that they had a booklet in the production area that listed all flight menus and the necessary ingredients, so that every chef followed a standardised way to produce the menus. The reason behind was for any chef in the hot kitchen to have the capability to produce the menus with equal confidence and standard. For Flight Catering Company A and B, the food production department produced all hot food that included hot meals, hot breakfast and hot snacks, except kosher meals. The hot kitchen only produced all first and business class meals in house while economy class meals were all outsourced from 3 food manufacturers. However, for business class meals, virtually everything was produced in house. For instance, all the dressings, sauces and salads were produced by themselves. In order to produce oriental menus for Flight Catering Company A’s major customer, JAL (Japan Airline), a specially allocated kitchen separated from the other kitchens, with 2 Japanese chefs in charge was setup. The GM explained that the employment of the two Japanese chefs could cater to Asian airlines’ menus:

*We use the Japanese chefs to make every single sub-meal component, whereas a lot of places would buy that in. It means we can go for a lot of*
items that you just can’t buy. So we will be able to make many more Japanese components than you will be able to get in a Japanese restaurant. We make all the meals for Japanese airlines. We also do meals for Korean and we now offer sub-components to Cathy Pacific and Singapore. We use their skills to cross use individuality elements.

As for Flight Catering Company C and D, no hot meals were actually produced. They only performed assembly of meals such as sandwiches, where all the ingredients were bought from other manufacturers. However, both units were still capable of providing 25 different types of special meals. Flight Catering Company A and B also offered special meals. The head chef of Flight Catering Company B explained the considerations they had to take for special meals, how they came out with enough products to cover passengers’ special requests and how they coped with last minute special meal request:

*When planning special meals, we take into considerations such as religious requirements - kosher, Hindu, Muslim as well as personal requirements - vegetarian, low salt, diabetic and low cholesterol. The list of special meals include: diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non dairy, high fibre, bland and low protein meals. In the hot kitchen, there is a booklist that shows all ingredients allowed in a special meal. Our staff will strictly follow the booklist guidelines which make the preparation of special meals easy to follow. In the case of last minute request, for instance, if there is a request for one additional diabetic meal, we will use other ingredients to replace*
them and avoid any cakes, chocolates, fatty fried foods, jams puddings or any syrups on it. Of course, we have to inform the airline companies if we cannot provide the regular diabetic meal as our contract stated. In addition, we make sure we have enough products to cover passengers’ special requests. For instance, plain chicken apart from using it in regular hot meals can also be used for low fat, diabetes, low cholesterol as well as children meals. These types of special meals are produced using the airlines normal menu as a guideline and adapting the products to suit the specific requirement. Special meals are always clearly labelled with passenger’s name to ensure the correct meal type is passed to the right person. For Kosher meals, it is usual to ask for 48 hours of preparation time requirement to enable us to order and receive the meals from the nominated authorised supplier.

All four units said that special meals could be ordered through the passenger’s travel agent at the time of booking. The airlines would then advise them at the time of ordering, all meals for a particular flight. This normally happened 24 hours prior to flight departure. Special meals were always clearly labelled with the passenger’s name to make sure the correct meal type was passed to the right person. In the event of a last minute special meal request, for example, one additional diabetic meal, all four units indicated that they used other ingredients to replace any high sugar content items and avoided the use of any high sugar content items such as cakes, chocolates, jams or syrups.
All four flight catering companies said that airline companies requested them to change menus from time to time so that passengers would not be bored of the same menu. For charter flights, meals were provided for a set period in time. Every airline rotated their menus for various times of the year, with most airlines requested to change their menus monthly. Table 8.4 shows an example of 3 menu rotations in a year for United Airline long haul flights.

Table 8.4 An example of how menus were rotated throughout the year

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cycle</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Finally, a summary of the workforce in the hot kitchen and number of menu rotations for each unit is given in Table 8.5

Table 8.5 Workforce in the hot kitchen and menu rotations for each unit

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of chef</td>
<td>4</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of junior chef</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Number of menu rotation</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Clearly, the nature of the flight catering business dictated their operations to be agile, evidenced by the need to cope with last minute requests before flight departure, special meal requests and the need to change menus regularly. In dealing with these issues, the units adopted the concept of modularity; where commonality in ingredients was adapted in the different meals and menus. Thus, the concept modularity allowed a wide of variety of products to be manufactured at a relatively short time and at low cost.
8.3.7 Food assembly

8.3.7.1 Dish packing

The next procedure was to assemble the prepared items into meals. The items were taken from fridges and assembled in accordance with the specification and photographs of menus. All items were labelled with a colour code label that clearly identified the day of production. Labels were also used to identify meal types, such as meat entree, fish entrée, and poultry entrée. All these labels were purchased printed. The dish packing, tray setup and trolley assembly were all allocated in the production area, specifically in the center of the kitchen unit for the convenience to receive any items for assembly from the different departments.

8.3.7.2 Economy class and business class dish packings

There were a number of methods for assembling meals - table-top, conveyor belt or workstation. In Flight Catering Company A, dish packing was done using table-top and conveyor belt. All E/C dish packings were performed on the conveyor belt, while all B/C dish packings were assembled on the table-top. The unit said the rationale behind was due to the fact that business class meals had more sub-components than economy class meals, which were easier to assemble on a table-top. Their internal process manager commended on the efficiency of the conveyor belt but also questioned about the use of conveyor belt to perform salads and pastries assembly:

We talked about the belts and tables. You can see the belts, how good it is running for the assembly of Singapore airlines breakfasts now. A good belt cannot stop, a good belt runs from the first day to the last day. That's a good belt so you can see for yourself if it's a good belt or it isn't. And good
practices, 6 trays on the belt, not 5, not 7 but 6 trays on the belt. If you do 6 trays on the belt and if the belt keeps running, this is the most efficient way to produce meals. You make the most meals per person per hour. For sub-components, we are developing to do that built on tables instead of belts. Salads and pastries are done on belts still but we need to investigate if we need to change it over to table production.

Indeed, on the day of audit, it was observed that 2/3 of the belt space was not in use for the assembly of Surinam Airways, E/C salad (see Figure 8.4). Although the internal process manager of Flight Catering Company A claimed that maximum efficiency was obtained with 6 trays on belt, but all the other three units did not impose any rule for the number of trays on the belt. It was observed that all the other three units, in general, put 2 trays on the belt.

Figure 8.4 Four operators performing E/C salad assembly for Surinam Airways on a conveyor belt in Flight Catering Company A

Dish packing for Flight Catering Company B was performed on table-top and workstation. Again, all B/C dish packings were done on the table-top, while E/C
breakfast and E/C cold dish were assembled on the workstation and table-top respectively. As for Flight Catering Company C and D, all E/C and B/C dish packings were performed solely on the table-top.

The Figures below summarised the assembly method employed and the average labour time used to complete one dish for each unit recorded on the day of audit. B/C meals in general possessed more sub-components and therefore, took longer to assemble than E/C meals as evidenced by figures shown in the table below. For instance, in Flight Catering Company A, an E/C breakfast with 4 items assembled on a table-top took only 19.69 seconds for each person (see Figure 8.5) while a B/C Western breakfast with 6 items required 52.94 seconds per person (see Figure 8.6). As a result, it shows B/C meals took longer to assemble than E/C meals.

Figure 8.5 Operators performing dish packing on a table station in Flight Catering Company A
Although there existed different assembly methods where the best method was adopted in the opinion of the units studied, a simple comparison that arose from the table below could verify the merits of the assembly method employed. In consideration of consistency in comparison, only the same number of dishes, same number of items in each dish and same number of operators allocated were compared. Within the same unit where practices and regulations were the same, a comparison between the performances of the conveyor belt and table-top in Flight Catering Company A was made. Unfortunately, on the day of audit, there were no same number of items for an E/C dish; so the closest number of items were taken for an estimate comparison. With three operators assembling 16 E/C desserts that consisted of 3 items on a table-top, the time taken for each person to complete one dish was 5.3 seconds. To assemble 16 E/C salads of 4 items by three operators on a conveyor belt, took 4.5 seconds per person per dish. Thus, the conveyor belt was slightly faster than the table-top.

On a cross case comparison, the performances of assembly methods using conveyor belt and table-top for E/C meals, could be drawn but one has to take into account other factors such as different practices in different units. For two operators assembling 16
E/C salad dishes with 2 items on the conveyor belt in Flight Catering Company A, the average labour time for each dish per person was 2.65 seconds. However, for two operators assembling 16 E/C appetiser dishes with two items on a table-top in Flight Catering Company D, the time taken was 3.75 seconds to complete one dish for each person. Again, there was not much difference between assembling E/C meals on a conveyor belt or on a table-top, with the conveyor belt slight being faster. An interesting finding arose between the assembly of B/C meals on a table-top for Flight Catering Company A and C. For one operator assembling 16 B/C dinner courses with 7 items in Flight Catering Company A, the average labour time for each course was 48 seconds; while an operator assembling 16 B/C cold meals with 4 items in Flight Catering Company C took 41.25 seconds for each meal. Evidently, the number of items for the B/C cold meals was less than the B/C dinner course, but the former took longer to complete for each meal.

The table below summarised the different assembly methods employed in each unit and the average labour time used to complete one dish.
Table 8.6 The average labour time for dish packing E/C and B/C meals

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>Dishing</th>
<th>Assembly Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>E/C Breakfast</td>
<td>Table top</td>
<td>1</td>
<td>4</td>
<td>19.69 seconds</td>
</tr>
<tr>
<td></td>
<td>E/C Desert</td>
<td>Table top</td>
<td>3</td>
<td>3</td>
<td>5.3 seconds</td>
</tr>
<tr>
<td></td>
<td>E/C Salad</td>
<td>Conveyor belt</td>
<td>4</td>
<td>4</td>
<td>2.1 seconds</td>
</tr>
<tr>
<td></td>
<td>Surinam Airways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E/C Salad</td>
<td>Conveyor belt</td>
<td>3</td>
<td>4</td>
<td>4.5 seconds</td>
</tr>
<tr>
<td></td>
<td>Iran Air</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E/C Salad</td>
<td>Conveyor belt</td>
<td>2</td>
<td>2</td>
<td>2.65 seconds</td>
</tr>
<tr>
<td></td>
<td>Continental Airlines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>B/C Fruit course Cathay Pacific Airways</td>
<td>Table top</td>
<td>1</td>
<td>6</td>
<td>110 seconds</td>
</tr>
<tr>
<td></td>
<td>B/C Western Breakfast Japan Airlines</td>
<td>Table top</td>
<td>1</td>
<td>6</td>
<td>52.94 seconds</td>
</tr>
<tr>
<td></td>
<td>B/C Dinner course Korean Airways</td>
<td>Table top</td>
<td>1</td>
<td>7</td>
<td>48 seconds</td>
</tr>
<tr>
<td>C</td>
<td>E/C Air Berlin cold meal</td>
<td>Table top</td>
<td>3</td>
<td>5</td>
<td>5.35 seconds</td>
</tr>
<tr>
<td></td>
<td>E/C Ford cold meal</td>
<td>Table top</td>
<td>3</td>
<td>8</td>
<td>13.1 seconds</td>
</tr>
<tr>
<td></td>
<td>E/C Ford cold meal</td>
<td>Table top</td>
<td>1</td>
<td>8</td>
<td>64 seconds</td>
</tr>
<tr>
<td></td>
<td>B/C LTU cold meal</td>
<td>Table top</td>
<td>1</td>
<td>4</td>
<td>41.25 seconds</td>
</tr>
<tr>
<td>D</td>
<td>E/C Air Berlin cold meal</td>
<td>Table top</td>
<td>2</td>
<td>5</td>
<td>7.5 seconds</td>
</tr>
<tr>
<td></td>
<td>E/C Air Berlin appetiser</td>
<td>Table top</td>
<td>2</td>
<td>2</td>
<td>3.75 seconds</td>
</tr>
<tr>
<td></td>
<td>B/C LTU sandwich</td>
<td>Table top</td>
<td>3</td>
<td>5</td>
<td>15.8 seconds</td>
</tr>
</tbody>
</table>

8.3.7.3 Tray setup and trolley assembly

Conveyor belts and table-tops were employed in Flight Catering Company A and C to perform tray setup and trolley assembly. All E/C trays were setup using the conveyor belt, while F/C, B/C and crew meals setup were performed on a table-top. Flight
Catering Company A remarked that, for large-scale flight meals, the setup of a conveyor belt was more efficient because the running speed of a belt could affect an operator's productivity. The operator had to match the speed of the belt as compared to working on a table-top, where the speed of an operator depended very much on how fast he/she desired. However, the unit manager of Flight Catering Company C lamented on the amount of time taken to set up the conveyor belt for each different airline:

_We have quite a few different airlines and that's our main problem. If you only have 1 carrier, then it's very easy. You always repeat the same process and you have to fit the conveyor belt just once. In that case, if you have 10 aircrafts, you just start the conveyor belt and off it goes. But we have so many different airlines and it takes a lot of time to reset the conveyor belt. That's very time consuming. In our unit, we are trying to assemble the same airlines at one go if the departure time is very close._

Flight Catering Company D, which employed conveyor belt for E/C tray assembly and table-top for B/C tray assembly; also advocated the idea of assembling E/C trays for the same airline at the same time. As their production manager put it:

_"To reduce the time for tray set up assembling, one operator or myself will set up the belt and prepare all the items in place before we start assembly. We try to assemble for the same airline company at the same time if possible. Thus, we don't have to re-set the belt again."_
Work station and table-top were the preferred methods of tray setup and trolley assembly for Flight Catering Company B. All E/C trays were assembled on work stations while assembly of B/C trays were performed on table-tops. The unit said that two and a half years ago, they used to have line layout with 3 or 5 operators working on the belt. They found that the significant difference between the work station and conveyor belt was the fact that the work station was more efficient and could easily trace back the responsibility of the person in the event of any mistakes committed. In addition, the unit remarked the disadvantage of the table-top, in that the setup of a table-top occupied more space for large scale flight meals. That was the reason they used work station for E/C tray assembly and table-top for B/C tray assembly.

Table 8.7 below shows the average labour time for each tray setup and trolley assembly for all four flight catering companies. Unfortunately, there were no B/C tray setups in Flight Catering Company D at the day of audit. F/C and B/C tray setups and trolley assembly were more complicated because of the larger number of items involved. For Flight Catering Company A, B and C, only one operator was assigned to perform F/C or B/C tray assembly, since these classes were specific meal requirements from the airline companies. The designation of a single operator in charge of these classes, gave assurance in the quality of assembly. Notice also from Table 8.7 that Flight Catering Company B and D had only 1 or 2 operators performing assembly for E/C trays, while Flight Units A and B had 3 to 4 operators performing tray setups for the same class. In Table 8.7, a comparison is made between the assembly of E/C trays on a work station and a table-top within the same unit; where the constraints mentioned back in section 8.3.7.2 (same number of trays, same number of items in a tray, same number of
operators) were considered. An operator assembling 16 E/C trays with 7 items on a work station in Flight Catering Company B, took 16.8 seconds (see Figure 8.7)

**Figure 8.7 One worker assembling Uzbestan economy class meals in Flight Catering Company B**

On the other hand, an operator assembling 16 E/C trays with 7 items on a table-top in the same unit, took 45 seconds. Evidently, the work station outperformed the table-top in tray setups and trolley assembly. Similarly, a cross case comparison was drawn between Flight Catering Company A and C. With 4 operators performing 16 E/C tray setups of 3 items on a conveyor belt in Flight Catering Company A, the average labour for each tray setup and trolley assembly was 1.71 seconds. In comparison, 16 E/C tray setups of 3 items on a conveyor belt by 4 operators in Flight Catering Company C, took 5 seconds for each person to complete one tray setup and one trolley assembly. Thus, E/C tray setup and trolley assembly on the conveyor belt in Flight Catering Company A was slightly faster than the same method of assembly adopted in Flight Catering Company C, but not significantly better (see Figure 8.8)
Figure 8.8 Operators performing tray assembly for LTU light meals on a conveyor belt in the Flight Catering Company C

The table below summarised the different assembly methods employed in each unit and the average labour time used to complete one tray setup and trolley assembly for E/C and B/C meals.
Table 8.7 Average labour time spent on tray setup and trolley assembly for E/C and B/C meals

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>Tray Setup and Trolley assembly</th>
<th>Assemble Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each tray setup and trolley assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>United Airlines E/C Conveyor</td>
<td>4</td>
<td>10</td>
<td>8.4 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surinam E/C Conveyor</td>
<td>4</td>
<td>3</td>
<td>1.71 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Japan Airlines E/C Conveyor</td>
<td>4</td>
<td>8</td>
<td>2.42 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulkovo Airlines E/C Conveyor</td>
<td>4</td>
<td>8</td>
<td>2.03 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continental Airlines second meal E/C Conveyor</td>
<td>4</td>
<td>4</td>
<td>1.09 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continental Airlines dinner meal E/C Conveyor</td>
<td>4</td>
<td>6</td>
<td>2.03 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Korean Air B/C Table top</td>
<td>1</td>
<td>9</td>
<td>75 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Japan Airlines crew meal Table top</td>
<td>1</td>
<td>9</td>
<td>150 seconds</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Turkmenistan E/C workstation</td>
<td>2</td>
<td>16</td>
<td>11.25 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uzbenstan E/C workstation</td>
<td>1</td>
<td>7</td>
<td>16.8 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continental E/C workstation</td>
<td>1</td>
<td>5</td>
<td>15 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continental E/C workstation</td>
<td>2</td>
<td>5</td>
<td>3.75 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Britannia E/C workstation</td>
<td>1</td>
<td>6</td>
<td>18.75 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Airtour E/C workstation</td>
<td>1</td>
<td>6</td>
<td>30 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mytravle E/C workstation</td>
<td>2</td>
<td>9</td>
<td>6.25 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scandinavian E/C workstation</td>
<td>2</td>
<td>8</td>
<td>15 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emirates B/C table top</td>
<td>1</td>
<td>7</td>
<td>45 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>British B/C table top</td>
<td>1</td>
<td>10</td>
<td>26.25 seconds</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Air Berlin E/C Conveyor</td>
<td>3</td>
<td>4</td>
<td>6 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTU E/C light meal Conveyor</td>
<td>4</td>
<td>3</td>
<td>5 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air Berlin E/C breakfast Conway</td>
<td>4</td>
<td>6</td>
<td>6.25 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air Berlin E/C breakfast Conway</td>
<td>4</td>
<td>6</td>
<td>6.56 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTU first class Table top</td>
<td>1</td>
<td>8</td>
<td>40 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EAE crew meal Table top</td>
<td>1</td>
<td>5</td>
<td>10 seconds</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Air Berlin E/C breakfast meal</td>
<td>2</td>
<td>6</td>
<td>5 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTU E/C light meal Conveyor</td>
<td>2</td>
<td>4</td>
<td>5.3 seconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air Berlin E/C additional meal</td>
<td>1</td>
<td>3</td>
<td>8 seconds</td>
<td></td>
</tr>
</tbody>
</table>
8.3.8 Despatch and loading areas

Food assembly workers sent trolley carts to the despatch area once the operators had completed assembly. Since the despatch areas in all four units were located near the food assembly area, not a lot of time was required to transport the assembled trolleys into the despatch areas. The average delivery time to transport the trolleys from the food assembly area to the despatch area took 20 seconds for Flight Catering Company C and D; while the time taken was 1 minute for Flight Catering Company A and B. The entire catering requirement for each flight was checked based on the despatch final flight figure obtained from the operation department which gave details such as the quantities of milk, lemons, ice, ice canisters, bulk rolls, hot water, and bar carts. Each airline company had their own waiting zones in order to distinguish the different trolley carts from other airlines.

Before the trolley carts were loaded on board, the practice in Flight Catering Company A and B was for the dispatch driver to check the quantity and quality of the trays in the trolley, who then sealed the carts after the inspection and sent them to the loading area. On the other hand, the above process was performed by assembly workers in Flight Catering Company C and D. After which the dispatch drivers transported the assembled trolleys to the loading area.

In general, the food was dispatched to the loading area 2 hours before flight departure. To ensure that four flight catering companies had enough time for loading, they had to compensate for transportation time to the aircraft. The dispatch drivers of all four units then checked the quantities of trolleys based on the final passenger figures before loading them onto the refrigerated vehicle; which were then loaded into the aircraft.
However, for Flight Catering Company A, an additional step was required before the trolleys were loaded into the aircraft. After the September 11 incident, Flight Catering Company A made it mandatory for all flights from United Airlines and Continental Airlines to have a security check by two dispatch men. In order to reduce the loading time, Flight Catering Company A allocated four employees that included one supervisor for each Japan Airline flight. Figure 8.9 shows a photograph of the despatch and loading areas in Flight Catering Company A.

**Figure 8.9 A photograph showing the despatch and loading areas in Flight Catering Company A**

The number and size of transportation varied for the four units. For instance, Flight Catering Company A had a transport fleet of ten trucks, one large van and 4 small vans; while the smaller Flight Catering Company D had 3 five tonnes trucks and 2 two tonnes trucks (see Table 8.8 for a summary of the transport fleet and drivers in each unit).

Bad planning in vehicle allocation could result in thousands of pounds of overspending, or problems in getting the meals onto the plane in time. Lorry drivers played a key role as the contact window with airline cabin crew directly. All the completed trolleys had to be loaded onto the aircraft 1 hour before flight departure. The used trolley carts
collected from the aircraft were uploaded into the vehicles before the newly assembled trolleys were loaded into the aircraft. The working shift arrangement of the drivers depended on the actual flight landing time and departure time. The table below summarised the despatch and loading area for each unit at the day of visit.

### Table 8.8 Summary of the despatch and loading area for each unit at the day of visit

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to transport from the food assembly area to the dispatch area</strong></td>
<td>60 sec</td>
<td>60 sec</td>
<td>20 sec</td>
<td>20 sec</td>
</tr>
<tr>
<td><strong>Time for food dispatched to loading area before flight departure</strong></td>
<td>2 hrs</td>
<td>2 hrs</td>
<td>2 hrs</td>
<td>2 hrs</td>
</tr>
<tr>
<td><strong>Transport fleet</strong></td>
<td>10 x 3 tonne truck, 1 large van, 4 small vans</td>
<td>8 x 7.5 tonne trucks and 16 x 17 tonne vehicles</td>
<td>5 x 3.5 tonne trucks</td>
<td>3 x 5 tonne trucks and 2 x 2 tonne trucks</td>
</tr>
<tr>
<td><strong>Employee for quality checking of assembled trays</strong></td>
<td>4</td>
<td>5</td>
<td>Lorry driver</td>
<td>Lorry driver</td>
</tr>
<tr>
<td><strong>Lorry driver</strong></td>
<td>25</td>
<td>42</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td><strong>Driver’s work shifts</strong></td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
8.3.9 Equipment area

In order to manage the high volume and high variety of equipment items, a list of part level code for each airline company were used by all four flight catering companies to assist their workers in their jobs. Each part item in the list was indicated with figures of maximum quantity and minimum quantity next to it. For Flight Catering Company A and B, a stock count on the equipment was conducted every month; while for Flight Catering Company C and D, a stock count was conducted weekly. If there happened to be shortage in equipment, all four units would get the necessary items from their warehouses. Alternatively, they would contact the airline companies by email and fax to request for the items, in order to make up for the shortage. The equipment storage area occupied the largest space in all the four units, even though the units tried to minimise equipment quantities in the storage as many as possible. Flight Catering Company A served two major customers from Asia, JAL and Korean Air, both which had very complex flight equipment. Table 8.9 shows the number of different items in the storage. Since Flight Catering Company A served many Asian long haul flights, they had approximately 3000 different items of equipment in the store, as compared to the 600-900 items in Flight Catering Company C and D that served only short haul or charter flights. All units were likely to have the same equipment of similar capacities, with large units FCCA and FCUB simply having more equipment items. This allows the large units to use their equipment more flexible, matching usage to demand.

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different Items of equipment in store</td>
<td>3000</td>
<td>1000-2500</td>
<td>600-900</td>
<td>700-900</td>
</tr>
</tbody>
</table>
8.3.10 Washing area

To avoid messing up all the equipment, all the four flight catering companies performed the wash up for the same airline company at the same time in one go, if possible. For heavily stained cups or plates, they would soak them into white plastic bins with cleaning agents and re-washed them again. Once all the equipment had been washed, the worker then sent them back to the equipment store. Once in the equipment store, the workers would count them. Flight Catering Company A had 2 elevators to assist workers to off load the complete flight equipment into the wash up area. Flight Catering Company A, C and D had their off loading areas different from the despatch area. In addition, Flight Catering Company C had a chill area for trolleys off loaded from the aircraft to reduce any bad smell from food.

In the wash up area, the number of items to be washed was based on the number of trolley carts that accommodated all items. Any waste food from the trays was put into one compactor. For Flight Catering Company C and D, lorry drivers had to take up the task of washing up in the wash area during off peak seasons, since there were less trolley carts to be transported during these periods. Hence, they had to make up for the shortage in labour hours by taking up the task of washing.

The percentage of disposable cutlery utilisation was dramatically increased after September 11 for all American airlines, where plastic cutleries replaced the entire metal cutleries previously used. On the other hand, some of airline companies used disposal trays for their second meal or snack box. An example of disposal items is shown in Figure 8.10.
As a result, Flight Catering Company B had 30% of disposal items, while Flight Catering Company C and D had 10-15% of disposal items. The disposal items were all disposed into the orange bins. A number of different techniques to remove waste from trays carried to the waste included: the holding area including bins, belt conveyors, screw conveyors, river or vacuum systems (Jones, 2003). Both Flight Catering Company A and B adopted the belt method to wash their equipment and dispose of waste. To ensure good flow on the belt, the trolleys were sorted according to flight class ie. first, business or economy class.

Glass bottles and cartons were disposed of separately. Because of the large number of equipment to be washed in Flight Catering Company A, they had 5 common track washing machines in the washing area and were categorised according to the different types of equipment each could handle. For Flight Catering Company B, there was less equipment due to the smaller number of long haul flights served. They had only 3 track washing machines. On the other hand, for Flight Catering Company C and D where both units served either charter or short haul flights, they only had one track washing machine each. The minimum number of workers allocated in the wash up area was two, where one stood in front of the washing belt to put the equipment on the belt; while the
other stood at the end of the washing conveyor belt to sort out the different equipment items and then put them into a basket. The washing of napkins and towels were all outsourced for the four flight catering companies. Table 8.10 summarised the washing area for each unit.

**Table 8.10 Summary of the washing area in each unit**

<table>
<thead>
<tr>
<th>Flight Catering Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing machine</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Technique to remove waste</td>
<td>Bin, Belt</td>
<td>Belt</td>
<td>Bin</td>
<td>Bin</td>
</tr>
<tr>
<td>Workers</td>
<td>7-8</td>
<td>7-8</td>
<td>2-3</td>
<td>2</td>
</tr>
<tr>
<td>Work shifts</td>
<td>2</td>
<td>2</td>
<td>2 (summer) 1 (winter)</td>
<td>2</td>
</tr>
<tr>
<td>Percentage of Disposal Equipment</td>
<td>20</td>
<td>30</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Waste management was a problematic issue for the four Flight Catering Companies. Waste management not only needed to have support from the airline companies, but the government also played a significant role. For Flight Catering Company C and D, all the bottles, cans, glasses and papers were recycled to the waste storage. The supplier would then give some money as incentives to the units for each recycled item. The two units must also follow waste manage regulations enforced by the German government in an attempt to reduce waste. Otherwise, the units would get fines or the possibility of shutting down by the government. Figure 8.11 shows the washing area in the Flight Catering Company A.
8.3.11 Bonded warehouse

Apart from food items, the four catering units all supplied duty free, liquor, tobaccos, perfumes and other gifts. For Flight Catering Company A, C and D, the duty free items were all supplied from their bonded store in their units. All the duty free carts were sealed and delivered to the despatch area. Only Flight Catering Company B had a separate duty free storage away from the main building, in order to facilitate custom checks by HM Customs and Excise at any time. To assist workers in assembling duty free goods, Flight Catering Company D had a catering instruction manual (CIM) which showed the quantities of duty free items and bar need to be loaded, and the standard loading figure for the workers to follow. For bar cart packing, workers assembled the bar cart according to the packing plan as specified by airline companies. As usual, Flight Catering Company A that served mainly long haul flights, spent more time than
the other units in assembling the bar carts. In addition, under the specific request of JAL (Japan Airline) who was one of Flight Catering Company A’s major customers; beer, wine and sakei were required to be chilled the night before departure. Flight Catering Company A confronted the problem where various items in the bar cart became jumbled up after a flight, so they sorted the items in the bar cart prior to reloading the carts. Hence, the unit said that time saving could be achieved in the region of 50 to 60 hours a week (see Figure 8.12).

Figure 8.12 Messed up bar cart in the Flight Catering Company A

8.4 Conclusion

This chapter primarily presented detailed descriptions of the operations in the four flight catering companies interviewed. Based on the empirical data reported, the following summarised the conclusion derived from the empirical research by multiple case studies. In order to achieve targeted goals and standards, all the four catering units employed certain Key Performance Indicators (KPIs). The KPIs ensured the elimination of any idling time, which does not contribute to the workers’ productivity. As discussed back in Chapter 2, lean is a concept that removes ‘anything’ that does not add value to a company. Hence, KPI is one of the methods employed by the four flight catering
companies to eliminate waste. Forecasting is a crucial factor in the prevention of overstocking and all four units were found to have MRP implementation via IT systems. The production planning was heavily reliant on the actual flight figures and estimated quantities of ingredients generated by their computer systems, which then allowed them to eliminate waste. As such, the implementation of MRP had enabled the units to realise both lean production and JIT. In addition, all the four flight catering companies employed the concept of ‘first in first out’, where food items that arrived in the store first, were utilized since they would expiry earlier than other items that arrived later. In this way, any unnecessary waste that arose from expired items was prevented. Again, this was another method to eliminate waste and achieve lean production.

To supplement the shortage in workforce during peak seasons, temporary workers were employed in all four units. Sometimes, workers in different departments were shuffled to work in other departments where more manpower was needed. Generally, the shuffling of workers was within the same process. However, Flight Catering Company C further extended the cross functionality of workers in other processes, for instance, drivers taking up the task of washing in the wash up area. During peak seasons where there were a lot of loadings and unloadings, the drivers not only had to perform the primary task of delivery, but also washed up all the unloaded equipment from the aircraft. Instead of allocating more manpower, Flight Catering Company C setup a chill area, where all the unloaded equipment were placed; while the drivers continued their delivery work. The chill area not only prevented the unloaded equipment from overcrowding the wash area, but also removed any smell from the remaining food on the equipment by keeping the temperature cool. When the drivers had completed their loadings and unloadings, they then picked up the unloaded equipment from the chill
area for washing in the wash area. Similarly, the functionality of drivers in Flight Catering Company D extended beyond their main process; where they were required to take up the task as storemen during their off duty hours. Thus, the concepts of functional and temporal flexibilities were clearly exhibited by all the four flight catering companies.

The nature of the flight catering business dictated the need for their operations to be agile, evidenced by last minute meal requests before flight departure, special meal requests and the need to change menus regularly. To cope with the high variety of menus and special meals, common food items were adapted to provide the wide range. This was clearly an example of modularity discussed back in Chapter 3. The concept of modularity was also observed in the wash up area of the four flight catering companies. Flight Catering Company A and B installed a machine that could process the different items that included glass, metal and plastic all at the same time. As such, the issue of variety was eliminated. Further, Flight Catering Company C and D grouped together items to be washed by the same airline, albeit different flights. This meant that the belt was not required to re-setup again for each different flight and therefore, would not cause any disruption to the workflow. By grouping together items of the same airline, standardisation across the different flights was achieved, which evidently advocated the concept of modularity.

The analysis of dish packing and food assembling showed that there was not much difference between the performance of E/C dish packing on table top or conveyor belt, with the conveyor belt slightly faster than the table-top. The efficiency of the conveyor belt was largely dependent on the first person in the line, who was responsible for
maintaining the same speed as the belt. Table-top was still widely adopted not only for assembling dish packing by the small units, but also broadly used for assembling business class or first class meals. The food preparation of long haul flights was more complex and the labour hours spent were higher than those serving short haul flights or charter flights only. The next chapter integrates the three phases of the primary research with a theoretical framework in order to interpret the results with reference to the secondary data. The conclusion arising from these discussions are discussed in the next chapter.
Chapter 9 Discussion

9.1 Introduction
The literature review of this study identified that the concept of MC allowed high volume and high variety to be achieved in the flight catering business. The first stage of exploratory study was to investigate and determine if MC could exist in current flight catering operations. As a result, the flight catering industry was categorised as 'flexible resource call off MC' by comparing processes in the MC model proposed by McCarthy et al. (2003). Having established the mode of MC, the second stage of the main study employed DEA to select efficient and inefficient flight catering units for case studies. These cases were used to identify the precise polices and procedures that flight kitchens adopted to achieve efficient operations and potentially implement mass customisation. It was proposed that the efficient flight kitchens would display more characteristics of mass customisation than the inefficient ones. This chapter discusses the implications of the findings presented in chapters 6, 7, 8 and makes a comparison with the previous literature discussed in chapter 2, 3 and 4. This chapter concludes with a re-evaluation of quantitative data.

9.2 Outcome of the implementation of MC in the flight catering industry
The flight catering industry is beset with the problems of coping with high volume and variety. LSG/SkyChefs and Gate Gourmet dominate over half of the worldwide market in the flight catering industry (refer to section 4.3 in Chapter 4), leading to increased homogeneity of operating practices. Mass customisation is a manufacturing strategy that enables high volume production at the low unit cost, while providing relatively customised or personalised products or services by adopting a range of policies, procedures and techniques in relation to the supply chain, production design and order
fulfilment processes (Gilmore and Pine, 1997). From existing published articles, the diverse opinions on the concept of MC made the definition of MC very confusing and difficult to define. The author analysed the literatures and identified what the author regards as the key elements of MC. MC is a combination of elements such as agile, flexible manufacturing, lean production, JIT and modularity. These concepts have also been reported to have positive impacts on the performances of manufacturing plants (Oliver, 1988; Womack et al., 1990; Grunwald and Fortuin, 1992; Pine, 1993; Forza, 1996; Levy, 1997; Christopher and Towill, 2000; Swaminathan, 2001). Hence, some or a combination of agility, Just-In-Time, modularity, lean production and functional flexibility should improve the efficiencies of flight caterers.

With the employment of DEA, efficient and inefficient flight catering companies were easily separated out for selection as case studies. The findings of these case studies identified the policies and processes adopted through the application of within case and cross case analysis, in order to understand the in-depth similarities and differences in operational processes.

9.3 Agility and flexibility

Agility is the ability of a company to produce a variety of products with high quality at a low cost. In other ways, agility is a business-wide capability that embraces organizational structures, information systems, logistics processes and, in particular, mindsets (Christopher & Towill, 2000b). This demands that the manufacturing system be simple and flexible. Flexibility is the key characteristic of an agile organization. Indeed, the origin of agility as a business concept lies in flexible manufacturing systems (FMSs). Functional flexibility is the key issue of workforce as the process of increasing the skill repertoire of workers in such a way that the employees acquire the capacity to
work across traditionally distinct occupational boundaries (Muller, 1992; Cordery et al., 1993).

The findings of this study found that all the flight catering companies demonstrated agility in their practices by transferring workers from tray assembly to cold assembly or despatch department in the event of any shortage in workforce. Generally, the shuffling of workers was within the same process. During peak seasons, temporary workers were employed in all four units to supplement the smaller core of workforce. The notion of flexibility was thus a very important role for the flight catering company to maintain smooth workflow while coping with high demands.

The agility in operations of all four units was evident in the event of flight delays. When a flight was delayed greater than 2 hours, flight meals which were already loaded into the aircraft had to be removed. This was done to prevent the possibility of food contamination (governed by Hazard Analysis and Critical Control Points) during the delay. Therefore, the caterer had to re-manufacture the meals again.

However, Flight Catering Company C further extended the cross functionality of their workers in other processes, for instance, drivers took up the task of washing in the wash up area. During peak seasons when there were a lot of loadings and unloadings, the driver not only had to perform the primary task of delivery, but also had to wash up all the unloaded equipment from the aircraft. Similarly, in Flight Catering Company D, the driver had to take up the task as a storeman to receive goods during his off duty hours. Since the role of the driver's required specific driving licence and because of this reason, they were paid higher than workers, for instance, in assembly department. In addition, the working shifts of lorry drivers varied, which were heavily dependent on the actual
flight landing and departure timings. The duration of each shift was generally 2 hours. Consequently, there would be times when the drivers were free. Thus, this was the rationale that spurred Flight Catering Company C and D to extend the cross functionality of drivers to other tasks such as washing up or receiving goods.

The adaptability of using common food items in main courses for specially requested meals illustrated the agility of flight catering company to deal with changes in product designs. For instance, Flight Catering Company B used plain chicken not only for the hot meal main course, but also for specially requested diabetic and chicken meals. Whenever there was a special request less than 5 hours before flight departure, all the four Flight catering companies would assess their available stocks and try to meet the demands if possible. This again showed agility in the operations of flight catering companies in coping with last minute orders. Another sign of agility was evidenced in the procurement of raw materials, where all the flight catering companies could edit the amount of stocks to acquire from the supplier in their IT systems. This flexibility ensured errors were minimised to a low level.

Airline companies requested changes to their menus from time to time in consideration of frequent travellers so that they would not encounter the same menu every time. As a result, all the flight catering companies had to deal with menu rotations from time to time as decided by airline companies. By using the same ingredients but different recipes, all the flight catering companies were able to conjure up different menus using the same food materials. This exemplified the implementation of the concept of agility in their operations. Flight Catering Company C and D were subsidiaries of the same company and thus, they were not involved in menu design directly with the customer. The menu design and specification were released from their head office by their special
menu design team through email or fax. Since Flight Catering Company C and D served the same airline companies such as Air Berlin and LTU; they shared the same menu specification albeit different flight routes.

9.4 Modularity

"Modularization of components to customize end products and services" is one of the five basic approaches to mass customization proposed by Pine (1993) in his book "mass customization: the new frontier in business competition". This concept implies assembling of different component parts of products or a combination of varied details of service. One product must be composed of several sub-assemblies; each part can be divided and manufactured separately. By changing these dynamic manufacturing flows, one can get a variety of products to satisfy customers' individual needs. Swaminathan (2001) divided modularity into products and processes, and then discussed the effectiveness of standardization strategy in mass customization practice. In his definition, a modular product is the combination of different components or subassemblies to manufacture one product which suits customer's individual options.

The flight catering industry had already adopted some key aspects of modularity, as they had modularised trolleys, trays layups and equipment. Modularity was distinguishable in the food production process of all the flight catering companies. In fact, the notion of modularity in all the flight catering companies was more or less the same thing. For Flight Catering Company A and B, they used the same equipment for the assembly of meals in different classes (economy, first and business classes). The same work station was used to setup and assemble trays for the different airlines. As for Flight Catering Company C and D, the conveyor belt was used to assemble the trays for different airlines. The use of common equipment to process the different types of items was an
example of modularity. Due to the fact that meals and equipment used for the same airline albeit different flight routes were very similar, Flight Catering Company C and D would assemble trays on the conveyor belt for the same airline in one go if their flight departure timings were close. In this way, the conveyor belt was not required to re-setup again which saved time and simplified the process. Again, this was an example of modularity where the same conveyor belt was used to assemble meals for flights of different routes but from the same airline.

Modularity was evident in the menus across the different classes (economy, first and business classes). In all the four units common food items, for instance, pasta and lamb, could not only be used for first and business class meals but also for economy class meals. Similarly, fresh fruits or vegetables could also be used as common ingredients for the different classes. Another indication of modularity was exhibited in the special meals provided by the four flight catering companies that included diabetic, low cholesterol and child meal. All these meals could be made up with existing food items if careful considerations were taken into account. All the units had a booklist that stated the kind of items that could and could not be used to make up a special meal. Any cakes, syrups and sugar for example, were not allowed in a diabetic meal. Hence, the booklist served as a standardisation to which all workers adhere to when making special meals.

The food preparation for long haul flights were more complex and the labour hours expended, were higher than the flight catering companies serving short haul flights or charter flights. For Flight Catering Company A, they had special meal specifications by contract requirements with JAL and Korean Air, which meant that the variety of sub-components they had to produce were more complex than the other airlines. The ingredients or materials for these sub-components were largely uncommon with other
airline companies and therefore made the sharing of materials, ingredients and equipment difficult. For instance, for producing a typical Korean main course, it was required to have specific Korean ingredients like Korean shiitake mushrooms, a Korean style of spinach. Moreover, for the Japanese cold noodles dish, Japanese soba (noodles) or Japanese soy sauce were necessary. In addition, to cater for JAL, a Japanese kitchen was specially setup in Flight Catering Company A, but all the equipment in the kitchen was only allowed to be used for the production of JAL meals. As a result, the more specific the request from an airline company, the greater the utilisation of production size and labour involved in the operational processes.

In the wash-up area, traits of modularity were found to exist also. For Flight Catering Company A and B, the wash up area consisted of 5 and 3 common track machines respectively, to wash different kinds of items ranging from glasses and metal cutleries to plastic trays. They eliminated variety by installing machines to enable processing them as if they were the same items, whether the items were glass, plastic or metal. Therefore, the same machine was used to process the different items of glass, plastic or metal. Since Flight Catering Company C and D served fewer airlines, they only had one washing belt each. Unlike Flight Catering Company A and B, workers of Flight Catering Company C and D had to manually separate the different items to be washed.

9.5 Lean production

Womack et al., (1990) defined the term “lean production” as the lean model that requires less stock, less space, less movement of material, less time to set up the machinery, a smaller workforce, fewer computer systems and more frugal technology. As well as responding to the need to be cost effective, this characteristic also constitutes a general principle that inspires a philosophy of essentiality and which makes every superfluous
element seem wasteful. Lean production is the minimum amount of materials, parts, space, workers, time etc required for a job, and it improves processes on an operational level as well as contact with suppliers. In addition, lean production is not only about minimal materials, parts, space, movement and time, but also about increasing the efficiency of workers to be more productive through elimination of waste. Waste in this sense is defined as anything that does not add value to the worker’s productivity.

All the flight catering companies interviewed provided training courses and set key performance indicators (KPIs) for their workers to achieve targeted goals and standards so as to become more efficient. For instance, in Flight Catering Company A, each worker had to achieve 55 tray setups per hour. In the washing area, the targeted KPI was 65 trays per person per hour. The target of KPIs set by the management for each unit varied, depending on the operational process in each different department. Thus, by providing training courses and targets to achieve for each worker, the efficiency of the workers should increase and reduce idle time or variations in task performance.

Further, Flight Catering Company A set a target for tray setups and dish packing performed on the conveyor belt. The number of trays on the conveyor belt at one time was targeted to be 6 trays. However, at the day the author interviewed the unit, some of the assembly teams were observed to adhere to the target set, but some of the other teams did not follow this policy. The timings recorded by the author on the day of interview found that there was not much difference between dish packing and food assembly of E/C meals on a table-top or conveyor belt, with the conveyor belt just slightly faster than the table-top. The efficiency of the conveyor belt was observed to be largely dependent on the first person in the line, who was responsible for maintaining the same speed as the
belt. If the first person in the line was slow, subsequent speed of other workers down the line would be slow too.

Another example of lean was the concept of ‘first in first out’ implemented in all the flight catering companies interviewed. Based on this concept, if there were two items but one arrived in store earlier than the other, the item with the longer storage period would be utilised first. Similarly in the hot food production, items that were produced earlier were utilised first, followed by the same items produced at a later time. In essence, the implementation of this concept allowed food items to be used within their expiration dates and in turn, reduced any waste that arose from expired food items. The items were colour labelled with stickers to distinguish the day they arrived into the store or the day they were produced.

As mentioned earlier that the notion of lean production is necessary not only in the elimination of unnecessary resources or materials, but also to include any step or process that does not add value. This was exhibited in the external processes of all the four flight catering companies, where they tried to create a global standardisation with airline companies. For example, the arrangement to transport meals straight from caterers’ assembled carts into the aircraft instead of transporting meals to airlines’ carts before being loaded onto the aircraft. The elimination of the unnecessary step of transporting meals to airlines’ carts before being loaded onto the aircraft saved both time and resources for the flight caterers. Apart from the flight catering company’s’ efforts to eliminate waste in their external process with the co-operation of airline companies, some airline companies such as BA and LTU, went further to help to realise lean production by minimising procedures in the supply chain management through the
provision of a webpage for flight caterers and suppliers that served them to assess; where they could check the estimated stocks the flight caterers possessed.

The airline companies were able to estimate the number of stocks the caterers had by the number of meals consumed after each flight as well as the number of trays, trolleys and equipment used. The suppliers would then automatically replenish the stocks for the flight caterer if they saw that the quantity was low. Hence, the airline companies contributed their parts in value creation in the supply chain process by the elimination of unnecessary procedures, where the need to constantly notify the airline companies' designated suppliers of the stock level was necessary. Lean production was also evident in the standardisation of procedures in different departments, allowing each worker to follow a standardised way of working in order to minimise any mistakes. For instance, there was a booklet in the food production of all Flight catering companies that listed all the menu and special meal specifications for the chefs to manufacture the meals in a standardised way. Hence, any mistakes would be minimised to a low level. To this end, waste was defined as the mistakes made by the workers that resulted in the production of wrongly specified meals.

As Womack et al., (1990) mentioned that less time to set up machinery was also one of the ways to achieve lean production, this principle was exhibited in Flight Catering Company D. The production manager of Flight Catering Company D would setup the conveyor belt during the break-time of workers. All the items needed to be assembled would be ready for the worker before they started to assemble. Outsourcing had became a direct solution to achieve lean production in all flight catering companies interviewed. In Flight Catering Company B, all E/C frozen meals were outsourced and the only meals produced in-house were F/C and B/C meals. Fruits for packing as a fruit salad dish were
outsourced from other manufacturers which arrived in the store already washed and pre-peeled. As a result, workers could start to assemble immediately and not waste any time on preparatory work like peeling of fruits.

The utilisation of IT in the forecast of meals required to produce for a particular flight was a major contributor to lean production. By estimating the number of meals needed, all the flight catering companies were able to reduce any excess stocks and thereby reduced any unnecessary waste. In addition, for Flight Catering Company A and B, any over produced meals on the condition that could not be adapted for use by other airlines; were sent to the company’s canteen rather than throwing them away. This prevented over production and at the same time, saved storage space which would otherwise be required to store these meals.

9.6 Just-in-time

In practice, minimum reasonable inventory (MRI) is a more relevant philosophy (Grunwald & Fortuin, 1992). Just-in-time (JIT) is the organizational principle on the basis of which every working activity must be supplied with the necessary components in the necessary time and in the necessary quantity (Forza, 1996). JIT delivery and inventories are the heart of lean production systems (Levy, 1997). With JIT the company gives up the expensive security supplied by excess resources and relies on the synchronization of its various departments (Oliver, 1988).

Forecasting is the crucial factor in the prevention of overstocking and all four units were found to have MRP implementations via IT systems. For instance, Flight Catering Company A and B had a flight catering management system and likewise, Flight Catering Company C and D had a X-Net system. The production planning was heavily
reliant on the actual flight figures and estimated quantities of ingredients generated by their computer systems, which then allowed them to eliminate any unnecessary waste. Flight Catering Company A and B indicated they tried to produce meals as fresh as possible that resulted in the company’s work schedule of producing meals in the morning for afternoon and night flights. Vice versa, meals produced in the afternoon and night were for the morning flights. In particular for Emirates airline, one chef would come in at 2 am in the morning to prepare and cook all ingredients. For Fight Catering Company A, all the JAL flight meals had to be produced at the same date as flight departure. Therefore, everything was prepared just in time to avoid any wastage and enforced the high food quality. In addition, JIT production minimised the storage of ingredients which were expensive to store.

9.7 Recommendations in areas for further improvements

From the observations the author had gathered, two units lacked the aspect of creating a work environment that reduced waste. For example, things that are too far for workers to reach, they could be placed nearer. This situation was elaborated in Flight Catering Company A and B because of their larger unit size compared to Flight Catering Company C and D. The assembly workers at the worker station in Flight Catering Company A and B not only had to fetch items from another place but also had to prepare the food items all by themselves. Whenever there was shortage of some items, they had to stop the process of assembling and proceed to the equipment area or refrigerator to collect the items they needed. As a result, a lot of time was wasted in fetching items from one place to the other. A solution to this issue can be accomplished by the designation of an additional worker as a runner who will replenish materials from time to time so that workers are not required to leave their work stations to fetch materials.
Another area which can be improved on is the reduction of inventory in the stores of the four flight catering companies. Unnecessary inventory could take up a lot of expensive storage space. Due to the fact that Flight Catering Company A and B, served many long haul airline companies, they had more equipment compared to Flight Catering Company C and D. Particularly for the Asian airline companies, the equipment involved was more than 3 times the equipment required for charter airlines. In Flight Catering Company A and B, the quantity of equipment in the store was 3000 - 2500 different items; whereas the quantity was 600 - 900 different items in Flight Catering Company C and D. For the chilled items, Fight Catering Units A and B had 200 - 600 different items, while Flight Catering Units C and D had 34 - 40 different items. Therefore, all the four units especially Flight Catering Company A and B, need to do better to remove excess inventory that were not required in order to achieve lean production. Hence, the four flight catering units need to extend the adoption of JIT further in this area, where only required inventory at that point of time was acquired.

9.8 Re-evaluation of quantitative data

The conclusion from the findings suggested that there were some differences between efficient and inefficient units but it does not reveal significant differences in the adoption of policies and strategies between the efficient and inefficient units. This study has originally expected to find more revealing differences in the adoption of policies and strategies between the efficient and inefficient flight kitchens. Thus, this in turn raised the question of whether the rankings by DEA analysis had led to the selection of the most suitable four flight catering companies as case studies. It was therefore decided to re-evaluate the quantitative data.
A closer examination of the DEA results had indicated a general characteristic among the flight catering companies; the larger the unit, the more inefficient the unit was. In fact, the two inefficient units selected as case studies were much larger in workforce and building size than the two efficient units. Thus, simple productivity ratios of small and large were analysed, to determine if the performances of the units were indeed affected by size; in terms of workforce and physical building. The 134 international flight kitchens from the Momberger 2004 database were grouped into two, where the cut-off point taken from the means of the input variables determined their size. Flight kitchens with number of employees smaller than 288, and a physical building size smaller than 7857 m$^2$ were considered as small units. On the other hand, units with a workforce greater than 288, and a physical building size larger than 7857 m$^2$ were considered as large units. The results of Mann Whitney U test (Appendices 14 and 15) showed that there was a significant difference between the outputs generated by small and large units. The productivity ratios under the two groups; small and large units, were analysed and shown in Tables 9.1 and 9.2.

**Table 9.1 Simple productivity ratios of small and large units with no. of employees as input**

<table>
<thead>
<tr>
<th></th>
<th>Small units</th>
<th>Large units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate total no. of employees</td>
<td>9365</td>
<td>29833</td>
</tr>
<tr>
<td>Aggregate total no. of meal trays produced</td>
<td>2631802</td>
<td>5259814</td>
</tr>
<tr>
<td>Aggregate total no. of average flights per week</td>
<td>22836</td>
<td>34289</td>
</tr>
<tr>
<td>Aggregate total no. of airlines served</td>
<td>913</td>
<td>900</td>
</tr>
<tr>
<td>Productivity ratio of total meal trays produced to total no. of employees</td>
<td>281.025</td>
<td>176.190</td>
</tr>
<tr>
<td>Productivity ratio of total average flights per week to total no. of employees</td>
<td>2.43</td>
<td>1.14</td>
</tr>
<tr>
<td>Productivity ratio of total airlines served to total no. of employees</td>
<td>0.097</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Table 9.2 Simple productivity ratios of small and large units with building size as input

<table>
<thead>
<tr>
<th></th>
<th>Small units</th>
<th>Large units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate total square metres of building</td>
<td>297412</td>
<td>771163</td>
</tr>
<tr>
<td>Aggregate total no. of meal trays produced</td>
<td>3388964</td>
<td>4502652</td>
</tr>
<tr>
<td>Aggregate total no. of average flights per week</td>
<td>22345</td>
<td>34780</td>
</tr>
<tr>
<td>Aggregate total no. of airlines served</td>
<td>1010</td>
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<td>Productivity ratio of total meal trays produced to total square metres of building</td>
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</tr>
<tr>
<td>Productivity ratio of total average flights per week to total square metres of building</td>
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<td>0.045</td>
</tr>
<tr>
<td>Productivity ratio of total airlines served to total square metres of building</td>
<td>0.0034</td>
<td>0.00104</td>
</tr>
</tbody>
</table>

From tables 9.1 and 9.2, an unexpected finding was revealed; that the smaller units were more efficient than the larger units. Theoretically, economies of scale would suggest that larger units should be more efficient than smaller units, but the opposite was observed here; where a smaller workforce was more efficient than a larger workforce and likewise, a smaller building being more efficient than a larger building.

One explanation for the smaller workforce being more efficient was possibly that the management of human resources was much more flexible in the smaller units, with workers allocated to work on a variety of tasks according to needs. On the other hand, a larger unit had a greater number of workers, with adequate designation of workforce for each task. Hence, there was far less requirement for workers in the larger units to work on various tasks and in contrast, the degree of their functional flexibility was less than workers in the smaller units. Another explanation was that the larger the unit, the greater the number of different customers the unit had to serve; which then led to increased complexity. The large number of different airline customers influenced the variety of production, levels of inventory and so on. Thus, the computed rankings of flight catering...
companies by DEA, where the case studies were selected from; were clearly influenced by the units’ sizes. This might explain why there was not much difference, in terms of operational practices in processes between the selected four case studies of efficient and inefficient units. To this end, their performances were based on their sizes, rather than solely adoption of MC practices and strategies. A more appropriate approach in the selection of cases for this study is to use the BCC model (see in section 5.9.6 of Chapter 5) in DEA for analysis. This model is based on a variable return to scale. Hence, the size factor is removed from the analysis and any factors affecting performances could be argued to be solely attributable to their operational practices and strategies.

Table 9.3 summarised the DEA efficiency scores under the BCC model. By comparing the BCC efficiency rankings with the CCR efficiency rankings (refer to Table 7.9 in section 7.4) back in Chapter 7, the two selected 100 % efficient units under the CCR model were still 100 % efficient under the BCC model. Likewise, the efficiency of one of the selected inefficient case units under the CCR model was 15.55 %, while the same unit was 16.01 % under the BCC model. The other inefficient unit in the CCR model was 45.2 %, while the same unit was 69.01 % in the BCC model. The almost similar efficiency rankings under the BCC model therefore, raised the question if the selection of case studies based on this model would find more differences in operational practices and strategies between the efficient and inefficient units. In the conclusion presented in the next section, explanations were provided to argue why not much difference would be found in operational practices between efficient and inefficient units, even when the size factor is removed in the analysis.
# Table 9.3 DEA efficiency scores under the BCC model

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Flight Kitchen Unit Name</th>
<th>Efficiency Score (%)</th>
<th>Unit No.</th>
<th>Flight Kitchen Unit Name</th>
<th>Efficiency Score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rarotonga Cook Islands</td>
<td>100</td>
<td>69</td>
<td>Dalaman Turkey</td>
<td>40.33</td>
</tr>
<tr>
<td>2</td>
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<td>70</td>
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<tr>
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<td>100</td>
<td>71</td>
<td>San Francisco 249 USA</td>
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<tr>
<td>4</td>
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<td>100</td>
<td>72</td>
<td>Venice Italy</td>
<td>37.85</td>
</tr>
<tr>
<td>5</td>
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<td>73</td>
<td>Milan Malpensa Italy</td>
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<td>Leipzig/ Halle Germany</td>
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9.9 Conclusion

The findings concluded in this chapter further advocated what the exploratory stage in this study found; that policies and practices associated with MC existed in flight catering operations. The main elements of MC were identified as, agility/flexibility, lean production, modularity and JIT. To date, the study of these elements has never been reported for the flight catering industry. The flight catering industry is faced with the dilemma of coping with high volume and high variety. Hence, some or a hybrid of the constituents of MC (agility, JIT, modularity and lean production) may improve the efficiencies of flight caterers. The findings gathered from the four case studies selected by DEA verified that these elements were present in their operations to some extent.

In order to avoid over-stocking of inventory and thus prevented unnecessary waste, all the four units implemented MRP via computer systems to help them forecast the required raw materials and ingredients. The existence of MRP implied that the units employed lean production, where the concept of lean is to eliminate any waste. Waste is defined as anything that does not add value to the process. Training courses and KPIs were installed for the workers in the units, in order to improve their efficiency and achieved the targets set. The four flight catering companies also exhibited the practice of 'first in first out' principle. In essence, the implementation of this principle allowed the food item with the earlier date produced to be utilised first. This in turn, reduced any waste that arose from expired food items stored beyond their expiration dates.

In addition, the nature of the business dictated the implementation of JIT, where the freshness of food was ensured by producing the food one day or half a day in advance prior to flight departure. Thus, any last minute changes in the number of meals to be produced, for example less passenger figures than expected, could be adjusted in the
food production process to prevent any unnecessary waste. Like lean production, the success of JIT implementation was attributed to IT systems which helped the units to forecast the required raw materials and ingredients.

The concept of agility/flexibility was clearly exhibited in all the four units. The workers in the units were not fixed to work on a stipulated schedule or job scope, but shuffled daily according to flight schedules obtained from the operation department to determine where workforce was most needed. However, the transferring of workers was normally within the same process, for instance, dish packing worker to work in food assembly. In addition, during seasonal peak periods, temporary workers were hired to supplement the smaller core of workforce in order to produce the increased number of meals for the holiday makers. In the nature of the business, the flight caterers often had to cope with unexpected circumstances that ranged from flight delays to last minute special meal requests. In the event of a flight delay greater than 2 hours, meals which were already loaded onto the aircraft had to be taken down because of the possibility of contamination which could be hazardous to the health of flight passengers. Therefore, the caterers had to re-manufacture the meals again in a short time and this showed agility in their operations to cope with such a situation. Further, the adaptability of using common food items in main course for last minute specially requested meals illustrated the agility of the flight catering companies to deal with changes in product designs.

Due to the nature of the flight catering business, modularity existed even before the concept of MC to enable caterers to cope with the high variety issue. Flight caterers had to offer a wide variety of menus, for instance in special meals there were; diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non-dairy, high fibre, bland and low protein meals. In order to cope with this
wide variety, all the units employed the concept of modularity. As an example, a low cholesterol special meal was made with existing materials and ingredients such as chicken which was also used in the production of main courses for economy, first and business classes. Another instance of modularity was the utilisation of the same equipment for the assembly of meals of different classes (economy, first and business classes) in all the four units. Similarly, the same work station was used to setup and assemble trays for the different airlines.

Although the case studies conducted had found some differences in operational practice between the units, this study had expected more differences between efficient and inefficient units. A re-evaluation of the quantitative data using simple productivity ratios, revealed the finding that smaller flight catering companies were in general, more efficient than larger units. This was a surprise because most manufacturing plants operate on economies of scale (larger units will generate more outputs). The computed DEA rankings in Chapter 7 reflected what was found by the simple productivity ratios; that the smaller units were more efficient than larger units. This implied that the DEA rankings were influenced by the size of the units and explained why there were not many differences between the selected efficient and inefficient cases. Two of the selected units were larger in workforce and physical building size, while the other two were much smaller. Hence, their performances could be attributed to the influence of their sizes. A more appropriate approach suggested for the selection of cases would be the BCC model in DEA. This model is based on a variable return scale, which means that only units of similar size will be compared. As such, the size factor that influenced the performances of units would be removed; and the differences between efficient and inefficient units were arguably, solely based on the adoption of MC strategies and practices.
Despite the effort to eliminate the size factor by the adoption of BCC model, the previously selected four case companies are still observed to be very similar in efficiency rankings in this new computed efficiency scores. Thus, it is arguable that the selection of cases under the BCC model would find more differences in practices between the companies. This could be mainly attributable to the lack of variables to define the volume and variety characteristics and therefore, could not address the elements of MC properly. As mentioned back in Chapter 7, the study was limited by the difficulty in obtaining enough samples with the original desired variables. Instead, the collection of data had to recourse to the Momberger database with a smaller number of variables. Another reason is possibly because the whole MC strategy, as a combination of the MC elements described; has yet to be fully realised in this industry. As mentioned back in chapter 3, one of the major enablers of MC is the implementation of a well connected IT infrastructure. The flight catering industry is observed to be mainly hindered by the lack of IT infrastructure and does not enable customers to establish a closer relationship and customise their products/services.

Although the flight catering industry was found to have traits of mass customisation, this industry is still not ready to fully implement MC yet. This is because flight caterers are heavily reliant on airline companies' requests and demands, since they are the only sole customer in this line of business. Airline companies as clients, nowadays, only request small scale of special meals for a small proportion of passengers. Therefore, there is no opportunity to examine or conclude here, that the flight catering industry could implement mass customisation in large scale in the future. Successful implementation of mass customisation mandates the need to have a strategy. However, the scale of mass customisation implementation may be too small in the flight catering industry to examine this issue. This study can confirm that current flight catering operations
possessed all the MC elements of JIT, lean, modularity, agility/flexibility, to enable flight caterers to deal with the volume and variety issue in this business.

The next chapter presents the conclusion that arose from these discussions; along with the recommendations for the direction of future work.
Chapter 10 Conclusions and Recommendations

10.1 Introduction

The purpose of this study was to determine if mass customisation had been adopted in the flight catering industry. However, mass customisation is a general concept which may include a number of dimensions such as labour flexibility, JIT, modularity, lean production, and flexible/agile manufacturing strategies. These were investigated in order to try to understand their relative contributions to improved efficiency. It was planned that the study would lead to an understanding of those changes that have lead to ‘improvement’ and those that have shifted the performance frontier, i.e. ‘betterment’.

This chapter summarises the findings from each stage for the research and discusses the outcome of contributions to knowledge, methodology and practice. The limitations affecting the study are presented and recommendations for future research are provided, that can be undertaken to further investigate the operational efficiency of the flight catering industry due to specific MC elements.

10.2 A summary of findings from each stages

This study begun with an overview of the literature review and had identified MC as a concept that allowed high volume and high variety to be achieved in the catering business, as discussed back in Chapters 2, 3 and 4. The research design of this study was divided into two stages; according to the stages developed within the methodology in Chapter 5 (refer to chapter 5 in section 5.7). The implications of the findings presented were described in Chapters 6, 7 and 8. The nature of the study was exploratory and descriptive enabled by qualitative and quantitative methodologies. In order to reach the goals of the study, a set of research aims were defined as follows:
Chapter 10 Conclusions and Recommendations

- To understand current flight catering unit operations and processes in relation to MC, and identify the MC mode of this industry according to the five fundamental MC modes proposed by MacCarthy et al. (2003).
- To measure and differentiate operational efficiencies of flight catering using DEA
- To identify and understand similarities and differences in these units
- To identify the policies and processes implemented in flight catering units that could lead to improved performance and mass customisation.

The first stage of the study (exploratory stage) was to understand and explore current flight catering unit operations and processes in relation to MC, and to identify the MC mode according to the five fundamental MC modes proposed by MacCarthy et al. (2003). This stage was conducted through a qualitative research design. Using data triangulation, data was collected from three sources. The first source was secondary data, principally from a recently published textbook (Jones, 2004), as well as trade publications. The second source of data derived from unstructured observational studies to six flight kitchens in the United Kingdom (UK). From initial observations, a grasp on the general idea of the operational processes in the flight catering industry was achieved. The third data set was obtained through semi-structured interviews with flight catering managers at ITCA trade show in Nice, France; all of whom had good knowledge of the flight catering operational processes.

MacCarthy et al.’s (2003) six processes were investigated namely, product design/development, product validation and manufacturing engineering, and order fulfilment realisation, order taking/co-ordination, order fulfilment management and post order processes. A second objective was to identify the terminology used in this
context for these six activities, as almost certainly flight catering professionals would not use the same terminology as MacCarthy et al. (2003). This ensured that the interview incorporated terminology and phraseology that respondents would be familiar with. The findings found that MC potentially existed in current flight catering operations. Further, the flight catering industry was categorised as 'flexible resource call off MC' (Mode E) by comparing processes in the MC model proposed by MacCarthy et al. (2003).

After the establishment that MC might have existed in current flight catering operations, along with the identification of the MC mode for this industry; Phase I of the main study began with the identification of high performing and low performing flight catering units for further in-depth case study investigations. As a non-parametric technique, DEA (Data Envelopment Analysis) was an ideal candidate for the differentiation of efficient and inefficient units because no prior knowledge of the efficiency functional form was required. In addition, DEA maps out a frontier that is synonymous to the performance frontiers defined by Schmenner and Swink (1998) (see in section 2.3.3 of Chapter 2). The underlying 'theory of performance frontiers' states the maximum performance that can be achieved by a manufacturing unit through resolving inefficiencies or adopting new strategies and policies such as JIT or TQM. It was proposed that current flight catering practices in catering companies could lead to a shift in their operating frontiers, due to the adoption of policies and strategies that make up the MC strategy. The data source for DEA analysis was from Momberger world directory of flight kitchens, with a listing of 134 complete usable international flight kitchens' data.
Two efficient and two inefficient kitchens determined by DEA analysis agreeing to participate in this study, were selected as case studies. In general, Flight Catering Company C and D had a workforce smaller than 50 employees in each unit, while the workforce of Flight Catering Company A and B was greater than 140 employees each. As for the physical building size, Flight Catering Company C and B occupied less than 1500 m² of floor space each. In comparison, Flight Catering Company A and B had a floor space of greater than 3000 m² each.

In Phase II of the main study, then proceeded with the objective to understand the operational practices of flight catering units based on mass customisation principles and determine and practices that lead to improvement in the flight catering operations. Data was collected through field visits, interviews, observations, audits and documentations from the selected four case companies mentioned earlier. The data analysis employed both within case and cross case analysis in to order to understand the in-depth similarities and differences in the operational processes of the flight catering units (refer to section 5.10.6 in Chapter 5) By within case analysis, the study determined that the four flight catering companies had some MC elements in their operations. In particular, implementation of IT systems to forecast and reduced unnecessary waste was a major enabler of both lean production and JIT. There was also a high degree of flexibility in the functionality of workers to perform different tasks. Using the method of cross case analysis, the findings of this study further concluded that the extent to which flight catering companies' implemented mass customisation was limited.

The concept of 'first in first out' was also exhibited in all four units, where items with the earliest expiry date were utilised first, to reduce any waste that arose from the expired items. In addition, standardisation of procedures was evident in all the four
units, where workers followed a standardised way of assembly or setting up meals in order to minimise any mistakes. Outsourcing was observed to become a recent trend in current flight catering operations to achieve lean production. Items such as fruits that were pre-washed and pre-peeled eliminated the need to waste resources and time on the washing and peeling process. Externally, the four flight catering units achieved lean with the removal of the unnecessary step of transporting meals to airlines’ carts before being loaded onto the aircraft. However, efforts to remove waste in the external process were still not enough, mainly dictated by the extent which airline companies would co-operate. A possible solution, exemplified by airline companies such as BA and LTU, was the enablement of IT that would allow airline companies, suppliers and flight caterers to convene at a common webpage and remove any unnecessary steps in the external procurement or supply chain process. As mentioned before, JIT is a concept that is closely related to lean and in particular, MRP (Material Requirement Planning) implementation via IT systems to forecast and reduced unnecessary waste was a major enabler of both lean production and JIT in the four flight catering units.

The concept of modularity was achieved in all the four units by using common food items across different menus (economy, first and business classes). In addition, the use of common equipment such as work station or conveyor belt to setup, assemble, or produce different food items was another example of modularity. Lastly, the concept of agility/flexibility was found in the operations of the four flight catering units. In the event of any shortage in workforce, workers were shuffled to support the demands; but normally within the same process. This clearly demonstrated the functional flexibility in their workers. In addition, during peak seasons, temporary workers were hired to supplement the smaller workforce. The notion of flexibility was thus a very important role for the flight catering company to maintain smooth workflow while coping with
high demands. Agility in current flight catering operations was exhibited in the event of flight delays more than 2 hours, where meals already loaded had to be discarded for the prevention of contamination; and the meals had to be re-manufactured again. Thus, the operations had to be agile to cope with this unpredictable last minute requirement. Apart from need to deal with flight delays, the four flight catering units also had to cope with last minute special meal requests. Surely, agility in their operations was needed to ensure the meet this last minute demand.

Using the method of cross case analysis, the findings of this study further concluded that the extent to which flight catering units implemented the MC elements in their operations explained the differences in efficiencies between them. A high degree of flexibility in the functionality of workers to perform different tasks in different departments was the extension of flexibility implementation found in the efficient units only. Drivers in the efficient units were found not only to perform the primary task of delivery, but also required to perform washing in the wash up area or receiving goods in the store. As the theory of swift and even flow (see in section 2.3 of Chapter 2) stated that the more even and smoother the workflow, the greater the productivity.

However, the requirement for a high degree of functional flexibility in workers in the efficient units raised the possibility of disruption in the workflow because the same worker was assigned with two tasks. One of the efficient units resolved this issue by the designation of a chill area where equipment to be washed were unloaded there first, while the drivers carried on their primary task of delivery. Only when the drivers had completed their tasks of delivery, would they transport the equipment to be washed in the chill area to the wash up area for washing. Similarly, drivers in the other efficient unit fulfilled their secondary role as storemen only during their off duty hours. As a
result, the greater the degree of flexibility, the greater the need to enforce a smoother workflow or even create a smoother workflow. The designation of the chill area was exemplary for the creation of a smoother workflow. In addition, the two efficient units further adopted the concept of swift and even flow by grouping together trays for assembly or equipment for washing for the same airline, albeit different flights. As a result, there was no requirement to re-setup the conveyor belt each time for a different flight and in turn, avoided disruption to the workflow. By grouping together trays and equipment of the same airline, standardisation was achieved across the different flights and minimised any interference to the workflow. To a certain extent, this exhibition of modularity was a major enabler to the creation of a smooth and even workflow.

In conclusion, although all the four flight catering operations were found to possess elements of MC mentioned earlier, there were not many differences in terms of MC operational practices and strategies. The differentiation between the efficient and inefficient units was the extension to the implementation of cross functional flexibility in their workers, as well as modularity; by grouping together common items for the same airline, albeit different flights to be processed in order to ensure a smoother workflow. As found out in the previous chapter, the flight catering industry does not operate on economies of scale. This was highly unexpected, as most manufacturing plants in other industries operate based on the principle of economies of scale. Where larger units would generate more outputs. Hence, the size factor determined the performance of the selected flight catering units, where the two smaller units were more efficient than the two larger units. As such, the limited findings in MC practices or strategies between the efficient and inefficient units were initially thought to be due to this reason. An investigation was carried out to examine this issue by using the BCC model in DEA to eliminate the size factor. However, the results showed that the
efficiency rankings of the previously selected companies as case studies in Chapter 7, were still very similar to this new computed ranking. As a result, it is arguable that the selection of cases under the BCC model would lead to finding more differences in operational practices and strategies, between the efficient and inefficient companies. One explanation could be possibly due to the limited number of variables in the DEA analysis, that limited the characterisation of volume and variety, and in turn, could not address the elements of MC properly. The difficulty in obtaining enough samples for the originally required number of variables was already mentioned in Chapter 7. Hence, this study had to be contended with data collection from the Momberger database, but with a smaller number of variables available. Another explanation could be the fact that MC is not fully realised in this industry, simply because the flight catering industry was observed to lack in IT infrastructure implementations. One of the major enablers of MC is a well connected IT infrastructure as mentioned back in Chapter 3. As such, the impediment in establishing a closer relationship with customers to allow them to customise their products/services; hindered the development of a full-fledged MC strategy.

10.3 Contributions to knowledge

Lockwood (2005:293) has commented on how importance the academic research process contributes to the world of knowledge as “Part of the work of the academic as a researcher is to create new knowledge-to find out things about the world that we have not known before or to re-examine current views of the world and shed new light on them. Part of the work of the academic as an educator is to make this newly created knowledge accessible, so that it might have influence on the world by encouraging the recipient of the knowledge to change their perceptions of the world and see it in new ways. Part of the work of the academic as writer of academic papers is to show where
there are lacunae in knowledge or understanding or perceptions and to help fill these gaps with insight". The contribution of this research to knowledge, as described below, is divided by three categories, theory, methodology, and practice.

10.3.1 Contributions to theory

This study sought to research operations management by adopting a number of theoretical positions, as follows:

First, the generic system model of operational processes and information system flow in flight catering industry was developed (refer to Figure 4.2 in section 4.4.5). Second, the existence of MC in flight catering operation was investigated and established for the first time. The study investigated the concept of MC in the context of one specific industry, enabling an in-depth study of one situational context. Most other studies of MC have been cross-sectoral studies.

Third, MC is a hybrid process of job shop and mass production to allow high volume and high variety without trade-off while allows customer to select, order, and receive specific product at the possible lower cost. The characteristic of MC was first mapped out on the comparison diagram along with job shop and mass production (refer to Table 3.2 in section 3.6.3). The comparison chart also demonstrates the configuration of MC's operation layout that formulate the process steps. In addition, the concept of MC was further developed in Table 3.3 (refer to section 3.7). This will allow future researcher to better understand the similarities and differences between some of the most referenced literature on MC.
Fourth, the specific MC mode adopted by this industry was identified as “flexible resource call-off” (Mode E) which is in relation to the five fundamental MC modes that was proposed by MacCarthy et al. (2003). As far as is known this is the first research, or one the first, to apply the MacCarthy et al. framework using primary research.

Fifth, this study is the first research to outline flight catering operational processes in relation to MC elements such as lean production, agility/flexibility, JIT and modularity. Of the MC elements present in current flight catering operations, the extent of which agility/flexibility will be implemented was found to be a major contributor to the improvement of efficiency. The higher degree of flexibility to the workers in the two smaller units that allowed them to take on different tasks in different departments, as opposed to the workers in the larger units where their functional abilities were never extended beyond the same process. In addition, the smaller units were designed by the much closer integration workspaces where then facilitated workers to fetch things or move around much quicker. This indeed contributed to the improvement of unit’s efficiency. The other reason for the larger units being less efficient was that they were found to possess more complex tasks, due to different and large number of airline customers they served. For example, more sub-components, inventory, tray items, special meals, etc, are involved for those airline customers such as Japan Airlines and Korean Airlines. Hence, they had to cope with the large variety issues that slow down their workflow severely. The implication have involved in the extended implementation of agility/flexibility leads to the realisation that the greater the degree of flexibility implementation in flight catering unit, the greater the need to enforce or create a smoother workflow.
Lastly, the study sought to investigate the theory of performance of the frontiers and the relevance of DEA measurement. The flight catering industry operates on dis-economies of scale, contrary to most manufacturing plant operations which are based on the principle of economies of scale.

10.3.2 Contributions to methodology

It is proposed that this is the first study to combine the approaches adopted in this way. The use of mixed methods involving both quantitative and qualitative methodologies is potentially a powerful way in which to investigate operations management (OM) phenomena. Until now, the investigation of MC has mainly been a conceptual framework that is of qualitative nature. As such, this study is the first to analyse efficiencies of flight catering units and model the performance frontiers using DEA analysis. As a non-parametric technique that does not require prior knowledge of the efficiency functional form and the ability to accommodate multiple factors, DEA was the ideal tool for this study.

To date, the efficiencies of flight catering units have never been reported in published articles mainly because of the reluctance of companies to divulge sensitive data, and the multidimensional complexity involvement in this measure. This study is the first to investigate the performances of flight catering units using the methodology of DEA.

10.3.3 Contributions to practice

As far as is known, there has been not much difference in current flight catering operations. The most significant finding from this study was the failure of units to achieve economies of scale. Within this, contributions of this research include the identification of labour flexibility, the efficiency of alternative set-ups for tray assembly,
the potential of JIT principles, the application of forecasting and MRP, and the existence of modularity in a variety of forms. Some of these that could enable more efficient operations are described as follows:

Extended cross-functional abilities of workers were found in the efficient units, as compared to workers in the inefficient units. In the inefficient flight catering units, the functionality of workers was confined mainly within the same process. In contrast, workers in the efficient units were assigned different tasks in different departments. However, it was found that the success for a high degree of functional flexibility came at the prerequisite of a minimal disruption to the workflow. Therefore, if the inefficient units extended the functional ability of their workers to work in other departments provided that minimal disruption to the workflow was observed; the efficiency of their operations should improve. Another way to achieve better efficiency in practice, was the fact that grouping of common items to be processed, instead of processing different items at the same time; would allow a smoother and more efficient workflow.

The debate between the efficiency of work station and table-top for the assembly of meals was also investigated in practice. By the adoption of within case analysis and taking into considerations such as the same number of meals, same number of items in a meal, same number of employees deployed; a comparison was made between the timings recorded to complete a meal on a table-top and a work station during the field visits. The work station was found to be a more efficient method than the table-top for the assembly of meals.

Also in practice, flight catering companies could benefit with the designation of a 'runner' to fetch items for the workers to assemble. This would result in saving time
from fetching things from one end to the other and allows minimal disruption to the workflow.

10.4 Limitations of the Study

As mentioned in section 5.9.4 of Chapter 5, in order to obtain rational DEA results, the sampling size must be significantly larger than \((N \times M)\); where \(N\) is the number of inputs and \(M\) is the number of outputs. Initially, the data was obtained from the Momberger database which had a listing of 134 complete usable international flight kitchens' data with 5 variables. However, for the interest of the study, it was desirable to have as many relevant variables as possible to capture the true essence of the flight catering industry. Therefore, the author started to contact flight kitchens throughout the world to obtain 12 variables which were discussed to be relevant, by using email and fax on the 8th and 16th of November 2004. Despite a low respondent rate, the author was able to solicit companies based on initial DEA results of data from the Momberger database that generated some interest in companies to allow the author to conduct field study visits. Nevertheless, the respondent rate was not large enough for proper DEA discrimination. At the same time, two flight catering conglomerates in the UK were contacted based on good network contacts to gather more data for DEA analysis.

Even though the author has very good network connections with industry people based in the UK, the initial plan to obtain data from them was hindered by changes in the management due to the lackluster airline business in recent years. The Gate Gourmet Heathrow unit in UK lost a very big contract and in order to cut down costs, employees were sacked which included the main contact: the manager of the unit. Similarly, LSG/SkyChefs reorganised all their UK units’ structures to improve their performances in order to cut down costs. The reorganisation resulted in changes in the management.
Therefore, all pre-established network connections were disconnected after changes in the management.

Nevertheless, the new management in these two units were contacted but met with different opinions across the management board. Some senior executives were interested in the study since the company could benefit from the research, but some were not interested. There were also some confidentiality issues involved in gaining access to the units and the disclosure of sensitive data. Since the author only had contacted them by emails and phone calls, the establishment of trust between the management and the author was very important. Hence, it was necessary to provide as much evidences as possible to convince them. Relevant information of the author’s background and the purpose of the research were provided in email contents. Additionally the author’s supervisor Professor Peter Jones, whose chair is sponsored by ITCA sought industry support. However, the response rate still failed to meet the required sampling size for proper DEA discrimination and the study had to recourse to the Momberger database with 5 variables.

Since the data in the Momberger database consisted of world-wide airline catering kitchens, field visits outside of Europe would be undesirable because of the high costs involved. Another limitation of this study was encountered during field visits to flight catering units in non-English speaking countries in Europe. Two of the visits were based in Germany which posed a language problem to the author who does not speak any German. Nonetheless, one or two employees in the units could speak some English and helped to translate what was said during the interviews. In addition, the author minimised the language barrier by writing down in English what she wanted to express.
This study found MC was not fully adopted in the flight catering industry. This was due to the airlines themselves limiting the choice to individual passengers, as well as flight customers not being aware of the MC service option. Caterers would love to have more selective menus on each flight, as they would be able charge higher prices for this service. However, most of the airlines fear the service will be adding significant cost without sufficient return. Up to now they have decided that this is not the service model for them. Thus, the capability is available for the flight catering company equipped with internet based systems, for the implementation of JIT service, but the airlines do not see this as adding value. However looking forward we may see airlines change and fully adopt mass customisation.

10.5 Recommendations for future research
The research has highlighted a number of aspects affecting the efficiency of operational processes in the flight catering industry through MC elements. The research could be streamlined further to identify the impact of each individual MC element on the efficiency of flight catering operations. In consideration of the high costs and time taken to conduct case studies, a quantitative approach would be much more desirable to achieve this objective. This research has laid the groundwork for the future quantitative approach just mentioned because flight catering operations have been identified in relation to the MC elements and therefore, facilitated the quantification of these elements quantitatively. As an example, agility/flexibility could be quantified by: 'number of functional tasks within the same processes and 'number of functional tasks in different processes'. Once all the MC elements had been defined quantitatively, DEA analysis can be employed to determine the impact of these elements on the efficiency. By the inclusion and exclusion of each quantified variable in turn, DEA can easily identify the impact of each MC element by the number of changes in efficiency scores.
among the dataset. If the number of changes is substantial, then that MC element is considered influential to operational efficiency.

This research or the aforementioned future work lacked the discrimination in the improvement of efficiency due to MC elements as compared to companies that do not implement these elements. As stated earlier in this chapter, the flight catering industry adopted MC elements in their practices and DEA analysis could only compare these units to the unit that best implemented these MC elements. Unless companies without practices of MC elements in their operations were included in the dataset, the DEA results from this research could not tell the improvement in efficiency as compared to a unit that had no implementations of MC elements. The reason why these units were not in the dataset is because the difficulty to find a company that had no implementations of MC elements of some sort in today’s operations. Hence, the other future work for this research is set forth to tackle this issue by the collection of historical data from a flight catering company instead; in order to determine the influence in efficiency at different periods in time. For instance, the company might have implemented lean production at certain time and would therefore have an impact on the efficiency.
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References


References


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References


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References


References


References


Bibliography


Bibliography


Bibliography


Appendices

Appendix 1 Construction of questionnaire for the exploratory study

Dear Sir/Madam,

As the PhD student currently exploring the operation processes in a Mass Customisation environment, especially in the in-flight catering industry. The following questions will be of great help in determining the operation process and its applicability in the airline catering industry.

1. Menu/Tray Set Development and Design
Who designs menus and menu combinations - the airlines, yourselves, or a combination of the two?

Do you have a team to manage this new product development process? For instance, do you have development chefs or other specialists (nutritionists)?

What is the typical lead time for the development of a new product? Is this the same tray set design?

Do you carry out testing of new menus or products? If yes, does this involve passengers?

How do you organise and identify regular meals with special meals, such as MOML (muslim meals) or SFML (seafood meal), on the same flight?

How do you calculate the amount materials of food/ingredients necessary to provide the menu for passengers?

How do you do tray sets ups – do you use conveyor belts or work stations or any other method? Why do u use this method?
Appendices

How do you make sure you have enough galley equipment to set up?

3. Flight Fulfilment Management
How do you control the processes to operate or assemble meal sets for departure on time?

What is the impact on the production operations when passengers choose their meals at the time they book their tickets?

Do you apply JIT in your in-flight operation? If so, in what way and what are the benefits?

4. Flight Fulfilment realisation
How do you manage flight delays?

Are there occasions when you delay a flight? If so, what causes this?

How do you manage the mix products – first class, business, economy, etc? Do you produce all in-house or do you outsource?

How do you ensure correct individual demand of passenger? (for example in first class)? What is the rule or standard process to dispatch these meals in your company?

5. Post Flight processes
How do you manage passenger’s complaints or suggestions? Which channel is used?

How do you manage airline complaints?

6. Flight Forecasting and Co-ordination
What is your opinion about passengers pre-ordering their meal when booking a ticket?

How do you forecast the number of tray sets to prepare for each flight?
7. Demographics
How long have you been working in the flight catering industry?
☐ Under 2 years
☐ 2-4 years
☐ 5-8 years
☐ 9-12 years
☐ Over 12 years

How many airline companies does your flight unit support?

What is the number of daily flight from your unit?

How many tray sets per day does your unit provide to airlines?

Thank you for your time and co-operation!
Appendix 2 A sample of the transcript from an interview

Dear Sir/Madam,
As the PhD student currently exploring the operation processes in a Mass Customisation environment, especially in the in-flight catering industry. The following questions will be of great help in determining the operation process and its applicability in the airline catering industry.

1. Menu/Tray Set Development and Design
Who designs menus and menu combinations – the airlines, yourselves, or a combination of the two?

   A combination of the two.

Do you have a team to manage this new product development process? For instance, do you have development chefs or other specialists (nutritionists)?

   We do have an Executive Chef and some specialists to do this.

What is the typical lead time for the development of a new product? Is this the same tray set design?

   It is hard to answer this question. It depends whether our Exec. Chef is busy or not. Sometimes Chef may propose 10 new dishes in a week, but sometimes once a month. It can be FC meals or a simple EYCL trayset.

2 Menu / Tray Set Testing and Process Engineering
Do you carry out testing of new menus or products? If yes, does this involve passengers?

   A meal presentation is periodically held for people from airline companies to taste or test the menu. This doesn’t involve passengers. After the menu is in cycle, there will be inhouse meal evaluations. These members include different department participants. All participants must finish a report on traysetting, eye appeal, spec etc. They just act like passengers.

How do you organise and identify regular meals with special meals, such as MOML (muslim meals) or SFML (seafood meal), on the same flight?
I don’t know what does “accommodate” mean.
While PRO hands over the special meals to OPS (Operation Department), all dishes are labeled with the name of special meals. Usually trayset section presets these trays and place on the upper area of meal carts. Finally the carts are also labeled how many special meals stowed in this cart. Our inflight coordinator can hand over these meals clearly to flight attendants.

For entrée, the sticker, identifying special meals, are also labeled on the lid of entrée.
For trayset sections, these special meals are not preset together with other normal meals. This is also to avoid mistake while they are working with conveyor belt.

Special meals are also prepared in the specific kitchen.

How do you calculate the amount materials of food/ingredients necessary to provide the menu for passengers?
CPCS is using a computer system – MPS II, menu planning system II, which was purchased from CPCS in HK. When all new menu are finalized, the recipe is input into the system. The recipe is not only providing the way to cook but also the waste rate, yield rate, etc. This is an important information to calculate the cost as well as the raw material. With a forecast meal number, PRO can simply place orders for raw material by the system spread out to break down.

How do you do tray sets ups – do you use conveyor belts or work stations or any other methods? Why do you use this method?
The reason is cost consideration. First class meals cannot be setup through belts since the dishes are not in common. There may only be 1 set of cheese tray, 1 fruit basket, 1 jug of soup. Most of the airlines serve their B/C and EY passengers by tray service. There aren’t greater than 2 types of traysets for Business class. Thus we can do it on a belt. Same reason is applicable to EY.

How do you make sure you have galley enough equipment for tray set up?
Most of the equipment (carts, chinaware, melaminware) are stored in our MHS (Material Handling System). While warewashing people finish their jobs, the
equipment will be sent to the system automatically. Before trayset people or PRO people to work, they request equipment per their demand. It usually happened two hours prior to flight departure. If equipment is not enough, we have sufficient time to withdraw them from warehouse or change warewashing schedule to overcome it.

3. Flight Fulfilment Management

How do you control the processes to operate or assemble meal sets for departure on time?

Loading meals on time is essential to our whole operations. Without punctuality, the excellent meals either cannot satisfy our customer. Before the meals are loaded in hiloader, there are two hours of cold holding time which is for chilling purpose as well as checking the meals. The two hours will be a very good buffer to prevent flight delay. In addition to this, the meal trayset time is set about 8 hours at least prior to departure time. For example, the meal, flight departing at 1300pm, are possibly preset at 0600 or 0700 am. It is another safety volve. As to the handover time from point to point in upstream procedure, individual handover time is also reached from various sections to sections.

What is the impact to the operation when the passengers choose their meals at the time they book their tickets?

Actually there is no big problem for special meal request as long as we have plenty of lead time. Mass-production can lower the cost. Customized products take more time and cost more. According to the mutual understanding, all special meals must be ordered at prior to departure time by 24 hours. If this is well followed, there will not be impact to operation side.

To upgrade our service to airlines, we take the orders for vegetarian meals even the order is made in short time. Because a lot of passengers don’t have any ideas about the service of special meals. They learn it when they check in.

To sum up, little impact to operation side do take place but not very serious.

Do you apply JIT in your in-flight operation? If so, in what way and what are the benefits?

We don’t apply JIT here because almost our operations are not done by machines. I do believe the system can efficiently reduce our cost if it is fully applied.
The disadvantage factors are 1) The meal are hand-made. 2) When cycle changes, the time for each dish changes, too.

4. Flight Fulfilment Realisation

How do you manage flight delays?
The question covers a lot of operations. All delay reports must be investigated and rectified immediately. Since handover time is set by various sections (you may also consider as check point), the delay become very rare.

Are there occasions when you delay a flight? If so, what causes this?
Occasionally there is a delay. As I mentioned earlier, we have set 2 hours of cold holding time before loading meals to hiloader. So most of the delay cases are caused by last minute meal order. To reduce the frequency of delay caused by last minute order, we also reach consensus with airlines about the quantity for top up.

How do you manage the mix products – first class, business, economy, etc? Do you produce all in-house or do you outsource?
In operations department, the meals of different classes are done in different workplaces. I don’t know what is the answer against this question. The first priority for concern is the schedule. Then they will find the flights with same menu. They can be cooked together. As for different classes, different equipment make people know clearly which class they belong to. Besides, we also have menu specifications (with printed pictures) to help them.

We do buy some finished product from vendors. It depends on the airline’s request. But most of the dishes are done by ourselves.

How do you ensure correct individual demand of passenger? (for example in first class)? What is the rule or standard process to dispatch these meals in your company?
An individual demand meal is indeed an special meal. It must be ordered at 24 hours prior to departure. The procedure is same as other special meals aforementioned.

5. Post Flight Processes

How do you manage passenger’s complaints or suggestions? Which channel is used?
We handover meals to flight attendants instead of passengers. Thus we don’t know what passengers complain.
How do you manage airline complaints?
At the beginning of each year, the company set up the goal about the complaints numbers. For PRO, the goal is set at XXX cases compared with meal numbers. For OPS, it is set XXX cases against flights.
All complaints must be investigated within 2 working days. The marketing department, which is responsible for complaints receiving and replying, will forward our investigation and rectification plan to our customers.

6. Flight Forecasting and Co-ordination
What is your opinion about passengers pre-ordering their meal when booking a ticket? Obviously this will promote the services to the passengers. That also means the meal choices are not finalized before all passengers finished checking-in. When a main course is decided, caterers have to deliver to the aircraft by additional trips. (The main loading/unloading are finished earlier.) Besides, due to time constraint, caterers are supposed to prepare standby meals to get rid of the potential delay.
If there are many flights using the same menu, it will be convenient for caterers to do so. Caterers can use the left meals for next flight.

How do you forecast the number of tray sets to prepare for each flight?
Usually 24 hours prior to flight departure, we receive the initial meal order. We immediately distribute the information to all departments concerned. Before 4 hours prior to flight departure, airline companies will update the meal numbers.
So depending on how many meals are ordered by airline companies, we will provide the number of meals accordingly.

7. Demographics
How long have you been working in the flight catering industry?
□ Under 2 years
□ No 2-4 years
□ No 5-8 years
□ No 9-12 years
☑ Over 12 years
Appendices

How many airline companies does your flight unit support? 11 airlines.

What is the number of daily flight from your unit? 20,000 main meals.

How many tray sets per day does your unit provide to airlines? 20,000 tray sets.

*Thank you for your time and co-operation!*

*You’re welcome.*
Appendix 3 Protocol Interview

A. Process

<table>
<thead>
<tr>
<th>A.1 JIT</th>
<th>A.2 Lean</th>
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<tbody>
<tr>
<td>2. What is JIT?</td>
<td>11. What is Lean?</td>
</tr>
<tr>
<td>4. What Food items outsourced?</td>
<td>13. How you schedule your staff?</td>
</tr>
<tr>
<td>5. How many items kept in storage less than a day?</td>
<td>14. What is the KPI key performance indicator?</td>
</tr>
<tr>
<td>6. How many items stored for longer time?</td>
<td>15. How does manager assess the performances of units?</td>
</tr>
<tr>
<td>7. What food items produced immediately?</td>
<td>16. How do you measure your unit?</td>
</tr>
<tr>
<td>8. What food items saved for later?</td>
<td>17. How do you measure each manager to assess their performances?</td>
</tr>
<tr>
<td>9. How is the process of preparing main course for large demand?</td>
<td>18. How system is organised</td>
</tr>
<tr>
<td></td>
<td>19. How system is managed?</td>
</tr>
</tbody>
</table>
### A.2 Modularity

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. Have you heard of Modularity?</td>
<td>yes, no</td>
</tr>
<tr>
<td>21. What is Modularity?</td>
<td></td>
</tr>
<tr>
<td>22. Why use work station?</td>
<td></td>
</tr>
<tr>
<td>23. Why use conveyor belt?</td>
<td></td>
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<tr>
<td>24. How many common food items across different airlines?</td>
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<tr>
<td>25. What items frequently delivered from suppliers?</td>
<td></td>
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<tr>
<td>26. Difference in preparing First/B/C/EY meals?</td>
<td></td>
</tr>
<tr>
<td>27. Process of tray setups?</td>
<td></td>
</tr>
<tr>
<td>28. Process of tray and trolley assemblies?</td>
<td></td>
</tr>
<tr>
<td>29. How you distinguish lastest food items produced?</td>
<td></td>
</tr>
<tr>
<td>30. Organisation of equipment in work space?</td>
<td></td>
</tr>
<tr>
<td>31. Organisation of resources in work space?</td>
<td></td>
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<tr>
<td>32. Organisation of processes in work space?</td>
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</table>

### A.3 Agility

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Options</th>
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<tbody>
<tr>
<td>33. Have you heard of Agility?</td>
<td>yes, no</td>
</tr>
<tr>
<td>34. What is Agility?</td>
<td></td>
</tr>
<tr>
<td>35. Types of training provided?</td>
<td></td>
</tr>
<tr>
<td>36. How frequently training provided for hot food production staff?</td>
<td></td>
</tr>
<tr>
<td>37. Can EC worker replace First class labour?</td>
<td></td>
</tr>
<tr>
<td>38. How you schedule your production?</td>
<td></td>
</tr>
<tr>
<td>39. How you manage if request is 2 hours before flight?</td>
<td></td>
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<tr>
<td>40. Assembly of meals for departure on time?</td>
<td></td>
</tr>
<tr>
<td>41. How you manage request for special meals you have not anticipated?</td>
<td></td>
</tr>
</tbody>
</table>

### A.4 IT Enabler

<table>
<thead>
<tr>
<th>Question</th>
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</tr>
</thead>
<tbody>
<tr>
<td>42. Information on number of meals requires?</td>
<td></td>
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<tr>
<td>43. Communication medium with suppliers?</td>
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</tr>
</tbody>
</table>
44. Communication medium with airlines?
45. Ensure enough galley equipment for tray setups?
46. Forecast tray sets for each flight?

### B. Input

#### B.1 Input - Volume

1. Total employees in company?
2. What is cycle time?
3. Employees in food production?
4. Total labour hours a day?
5. Labour hours in hot food production a day?
6. Labour hours for tray setups a day?
7. Labour hour for EY meals tray set up?
8. Labour hours on tray and trolley assembly for EY?
9. Total dish packing working hours?
10. Building size?

#### B.2 Input - Variety

11. Labour hours on tray and trolley assembly for first class?
12. Labour hours on tray setups for special meals?
13. Number of menus?
14. Impact of new menus to operations?
15. Impact of new menus to staff?

### C. Output

#### C.1 Output - Volume

#### C.2 Output - Variety
1. Weekly flights supported?  
2. Number of tray set ups a day?  
3. Hot meals produced a day?  
4. Charter meals produced a day?  
5. Number of dish packing a day?  
6. Number of bakery?  
7. Number of dry items?  
8. Number of bar carts a day?  

9. Number of airlines?  
10. First and business class meals?  
11. Special menu choices?

### D. Audit and observations of operational processes in flight catering industry

<table>
<thead>
<tr>
<th>AUDIT</th>
<th>OBSERVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accountable Items</strong></td>
<td><strong>Record Flow</strong></td>
</tr>
<tr>
<td><strong>D.1 Good Inwards</strong></td>
<td></td>
</tr>
<tr>
<td>1. Record items arrived in the morning</td>
<td>1. Take pictures in process of delivering items to store</td>
</tr>
<tr>
<td>2. Record items left at the end of the day</td>
<td>2. Size of the store</td>
</tr>
<tr>
<td>3. Items stored for less than a day</td>
<td></td>
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<td>4. Items stored for longer time period</td>
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<tr>
<td>5. Record number of different dry stores</td>
<td></td>
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<tr>
<td><strong>D.2 Food Production</strong></td>
<td></td>
</tr>
<tr>
<td>6. List type and number of equipment</td>
<td>3. Common resources grouped together</td>
</tr>
<tr>
<td>7. Number of workers</td>
<td>4. Common processed that are grouped together</td>
</tr>
<tr>
<td>8. Items stored before any request by airlines</td>
<td>5. Common equipment that are grouped together</td>
</tr>
<tr>
<td>10. Food items saved for later</td>
<td>7. Difference in preparing first/B/C/EY</td>
</tr>
<tr>
<td></td>
<td>8. Take picture in organisation of work flow</td>
</tr>
<tr>
<td></td>
<td>9. Picture in the process of producing hot meals</td>
</tr>
</tbody>
</table>
| D.3 Dish Packing | 11. List type and number of equipment  
12. Number of workers | 10. Take picture to see if all the workers in the conveyor belt station really working  
11. Picture in the process of dish packing |
| D.4 Tray and Trolley Assemblies | 13. List type and number of equipment  
14. Number of workers | 12. Take picture to see if they use the convey belt in an efficient way  
13. Picture in the process of tray assembly using conveyor belt  
14. Picture in the process of tray assembly using work station  
15. Picture in the process of delivering assembled trays into trolleys |
| D.5 Flight Assembly |  | 16. Take picture in the organisation of space in assembly area  
17. Take picture in the process of delivering trolleys into flight assembly area |
| D.6 On Load Docks |  | 18. Take picture to see if they use the transportation efficiently |
| **Measuring Flow** |  |  |
| D.2 Food Production | 1. Number of E/C hot meals produced in 10 mins  
2. Number of B/C class hot meals produced in 10 mins  
3. Number of First class hot meals produced in 10 mins  
4. Total labour hours at the end of the day |  |
| D.3 Dish Packing | 5. Number of cold items on tray over 10 mins in the morning  
6. Number of cold items on tray over 10 mins in the afternoon |  |
<p>| | |</p>
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<tbody>
<tr>
<td><strong>7.</strong> Number of cold items on tray over 10 mins in the evening</td>
<td></td>
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<tr>
<td><strong>8.</strong> Number of dishes packed for hot meals in 10 mins</td>
<td></td>
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<tr>
<td><strong>9.</strong> Total labour hours on dish packing at the end of the day</td>
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<tr>
<td><strong>D.4 Tray and Trolley Assemblies</strong></td>
<td><strong>D.4 Tray and Trolley Assemblies</strong></td>
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<tr>
<td><strong>10.</strong> Number of trays assembled and delivered into trolley cart in 10 mins using conveyor belt B/C EY</td>
<td><strong>10.</strong> Number of trays assembled and delivered into trolley cart in 10 mins using conveyor belt B/C EY</td>
</tr>
<tr>
<td><strong>11.</strong> Number of trays assembled and delivered into trolley cart in 10 mins using work station B/C EY</td>
<td><strong>11.</strong> Number of trays assembled and delivered into trolley cart in 10 mins using work station B/C EY</td>
</tr>
<tr>
<td><strong>12.</strong> Number of special meals trays assembled and delivered into trolley cart in 10 mins</td>
<td><strong>12.</strong> Number of special meals trays assembled and delivered into trolley cart in 10 mins</td>
</tr>
<tr>
<td><strong>13.</strong> Number of workers at conveyor belt for tray assembly</td>
<td><strong>13.</strong> Number of workers at conveyor belt for tray assembly</td>
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<tr>
<td><strong>14.</strong> Total labour hours at the end of the day</td>
<td><strong>14.</strong> Total labour hours at the end of the day</td>
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<td><strong>D.5 Flight Assembly</strong></td>
<td><strong>D.5 Flight Assembly</strong></td>
</tr>
<tr>
<td><strong>15.</strong> Time taken to prepare the trolley for one flight</td>
<td><strong>15.</strong> Time taken to prepare the trolley for one flight</td>
</tr>
<tr>
<td><strong>16.</strong> Time taken for all trolleys to assemble in the flight assembly area for one flight</td>
<td><strong>16.</strong> Time taken for all trolleys to assemble in the flight assembly area for one flight</td>
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<tr>
<td><strong>D.6 On Load Docks</strong></td>
<td><strong>D.6 On Load Docks</strong></td>
</tr>
<tr>
<td><strong>17.</strong> Time taken for all the trolleys ready to depart for one flight</td>
<td><strong>17.</strong> Time taken for all the trolleys ready to depart for one flight</td>
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<tr>
<th><strong>Mapping Flow</strong></th>
<th><strong>Record Flow</strong></th>
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<td></td>
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</tr>
<tr>
<td>D.1 &amp; D.2</td>
<td>1. Time taken to deliver items from store to food production</td>
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<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>D.2 &amp; D.3</td>
<td>2. Time taken to deliver from food production to dish packing</td>
</tr>
<tr>
<td>D.3 &amp; D.4</td>
<td>3. Time taken to receive all items from D3 before they start to assemble E/C B/C First Class</td>
</tr>
<tr>
<td>D.4 &amp; D.5</td>
<td>4. Time taken to deliver from trolley &amp; tray assembly to flight assembly</td>
</tr>
<tr>
<td>D.5 &amp; D.6</td>
<td>5. Time taken to load from flight assembly to dock</td>
</tr>
</tbody>
</table>

**E. Background**

Gender: [ ] Female, [ ] Male

Age: [ ] under 20, [ ] 20-35, [ ] 36-45, [ ] over 50

Your role and department in company?

How long have you been working in the flight catering industry?
Appendix 4 Interview transcript from Flight Catering Company A

Process control manager

Hot meals produced, then produced cooked in-house salad, then chefs do cook cold dish......the higher end, delicate type of work.

How do you organise your unit?
Various processes, first one is goods inward, purchasing and provision we have equipment supply which is equipment management and wash up and unit, we have food production which is assembly, cold assembly and all areas of tray set assembly and we have service delivery which is drivers and loaders that deliver the food to the aircraft.

How do you schedule your staff?
Each carrier has their own schedule so we have a production assembly schedule which is an Excel document, we have a back log schedule which is the wash area which again is an Excel document which helps them to manage the back log of carts and we have the loaders, equipment handlers schedule based on most of tonight’s schedule

Have you heard of KPI?
Yes. We have 2 main KPI...meals per hr and hrs per flight. A food related department works to meals per hr KPI while the guys who load the flight works to hrs per flight KPI. We have a number of other KPIs...cost per hr, meals per flight, on a day to day basis we use the KPIs to manage the
business and of course at the end of the week, we look at financial performance, how we did in terms of sale at the end of the week. On a day to day basis, we use the KPIs.

**How do you measure each manager to assess their performances?**

Again, each department has a KPI target and we look at historic data. We set within budget and look at historical data to set KPI target. On a day to day basis we look at their KPIs to assess managers.

Use work station.

**Do you have training courses?**

New staff will have induction training course, learning about the company, what it does. Then we have hygiene course, we have fire training, all the compliance training. Once the person is into the role then they will have on the job training.

**How frequently training for hot food production staff?**

Unusual. Unless something specialist, then we will look at specific training.

**Can EC worker replace first class labour?**

To a degree, we can do that. We wouldn’t take E/C worker and put them into hot kitchen. We can take tray assembly and maybe put them into cold assembly or dispatch. Normally within the process. Not like wash guy into tray assembly.

**How do you manage if request is 2 hrs before flight?**

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Depends on what request is. Around 10-20 meals is ok. If 747 came in and with no catering, then depends on size of aircraft, the types of meals. If 747 came in and ask for 3 classes of catering, then no. If a 50 seat came in, then we assess based on request, how long it will take us to do it. We do that by operator will take call, then they will speak to department managers and they would say this is what they want, what can we do. Internally, we will negotiate. We look at what we have.

How do you make sure departure on time?
Computer system. Part of it. We have assembly schedule, production schedule, is built so that the food is dispatched 2 hrs before it is send out to aircraft. So we always that far ahead. We have dispatch team checking the flight is there.

How you manage request for special meals you have not anticipated?
If forecast is provided 24 hrs, we can do it. If feasible to do it in short space of time, then we will do it. For example, request for colestraw meals…we only hold frozen ones, we don’t prepare them in house, so we need 24 hrs notification. Normally, special meals can be made abt the same time.

Where does all information come from?
Telex, fax. It’s the alpha computer system, it builds airline schedule, they have menu costing so each menu is broken down to its component parts and combination of menu and schedule enables the purchasing guy to produce an estimate for the day. We can edit that, increase or decrease. The computer says 10kg but I only have 8kg so I edit. This is purchasing forecast. Planning forecast, we use historical data.
Hot kitchen

Basically we do all the hot food on the hot on tray, so anything to do with hot meals, hot snacks, hot breakfasts, we produced all of them. Then we produced all the items that are cooked in house, cold meals, salads and some desserts. The chefs will do all the cold work as well, all the first class, business class for the long haul flights. We look after the higher end, little delicate type of work.

IT system

Very old computer system called the flight management system. Into that we put airline schedule, compile and cast menus specifications, we use it for purchasing and we also use it for billing and finding invoices, and I guess the starting pt is the airline schedule, it produces a daily worksheet of the list flights, schedules and operations update passenger figures. -24 hrs can be updated.

Operation department

The operation department is the day to day contact, they deal with operation changes, live operation changes, off schedule aircrafts, additional aircraft diversion and they also accept the passenger figures on a daily basis. So we know how many meals to make for departure.

Meal Racking
Dispatch chillier and Flight assembly

Depending on the new menu, we have to assess, normally the assessment of the impact of the change is normally done while we are producing the meals, while we doing it live. Particularly in terms of assembly, we look at what impact it makes to assembly time of the meal, so we maybe retime somebody would say it was 20 secs now its 30 secs and we build that back up again. Generally it would be done once the menu started rather
than pre. What tends to happen is we have menu presentation so we show the airline new ideas, new products and they will select which ones they want to use dependent on price. At that point, we are not assessing the impact on the assembly, quite often it will only assessed when it is put into use. Staff will normally get to see what the new menu look like.

**Work station assembly**

2 and a half yrs. Cellular layout. 3 or 5 people in the belt. Work station more efficient, perception is more efficient.

**Head chef:**

Airline choice, we buy them. Why outsourcing for all stuff? Budget issue? In the long run, we would like to do it ourselves, management looking for what is cheaper for them not for us.

Airline decide supplier, it’s going to be cheaper for them. So we have to purchase from their supplier so that’s being outsourced again. Apparently I asked my manager if we are going to lose money on that and he said no we are actually making, it’s actually cheaper. We buy ingredients, we manufacture in-house, put it together.

Any items stored less than 1 day: Forecasting, so do not have any waste. There is expiry on food, but with forecasting no waste. In the past, we do not have forecast, chuck away thousands of sandwiches…minimising waste each year.

For B/C, virtually everything is produced in-house, everything is cooked, all the marinate, all the dressing, all the sauces, we make everything, all the salads and then one chef will prepare it cook it and then the other chef will obviously do the layout and then go on to preparation again, so we keep all the preparation in line purely for the chefs. Seafood orders, the chef will prepare everything in the morning, everything is laid fresh and the
chef will come in at abt half 2 in the morning and do all the cold food for emirates. 3 chefs to do Emirates over 7 days. Everything is done fresh. We try to do everything as fresh as possible. How many hrs in advance? We finish everything by 10am, then someone will check the quality, the figure. Need to be loaded at about half 11. We do special meals. Cause any problem with special meal? Because you don’t know what you get. You have to make sure you have enough products to cover to satisfy everybody. But make sure they are common. Plain chicken….can use it for low fat, diabetes, low cholesterol….can use it on children. Try not to waste. Arty chores…roast asparagus, …lots of airlines do not have specific meals. Guide for diabetes, can’t have jam, fatty food….can understand what you can give, what you cannot give. Hindu, Asian, low protein. all of the main …just a guideline…don’t give sugar. Special meal index…explain what diabetes is ..at a glance, it’s allowed or not. Company used to provide course every year.

24 hrs, all special 24 hrs….if he forgets to order, airline says he is going to have …

Communication medium, phone…1 hr before departure, five B/C meals

Stopped everybody to get it done.

**How long to prepare b4 flight depart?** A day in advance.

Chef comes in the morning to cook at half 2 to cook. Do not freeze any F/C n B/C. E/C is frozen. How many days in advance for E/C? Do not do EC in house, all outsourced. Part of Alpha in Manchester; all they do is bulk E/C meals. They produce it n then freeze it. Each unit then orders from them. They can produce cheaper.
Where do you get all the information comes from?

Operations give all the information. Each chef will do different airlines. **Today's schedule is for tomorrow.**

With the cut off times, the airlines will accept passenger’s right up to the door closed which is good economics for everyone. What we have to do is to ensure that we need the aircraft ton time for loading, obviously we have to compensate for travel time to the aircraft, we have to compensate time for allocation to check and dispatch the flight and that would give us the production deadline, and then we can understand what time we have to be ready for to allow all the other people to do their jobs. That would allow production people to have a set time to allow them to do their work. For 2pm flight, 10am is my deadline. Usually is 3-4 hrs. Dispatch will come and put it into oven.

Common items like chicken, asparagus. Any flight items produced and used immediately... am produced for pm. Pm produced for am. Am for am like Emirates.

Chartered flight can produce the previous day

**Production team manager:**

We have 2 schedules. Schedule one, schedule two... schedule one is produced in the morning and produced all afternoon flights, schedule two produce afternoons which will produce all the next morning flights. So everyday we produce two schedules.

Every airline will work off menus for various times, most airlines will offer menus for 6 months, 6 months for the summer, 6 months for the winter. At the moment, we produce at 43000 meals per week. For summer, we produce about 85000 meals per week. Because during summer, people go
for holidays. BA run up to 3 rotations which change every week. Airline rotation chart. For long haul carriers...full rotation. Rotation in place because you don’t want the same meal each week. We never over produce.

Where figures come from? Man fly for Saturday and got all the figures...BA will send all the figures by email or by fax.....aircraft type...trolleys have to be changed.

Every catering has their own ways to label. When we open and dish it out, we need to track, it will be labelled, we know it’s made today. Everyday is a different colour. There is a wastage tray so we can track back the wastage cost. Friday is blue, yellow is Saturday, Sunday is pink, Monday is white, Tuesday is red, Wednesday is brown, Thursday is brown.

Heathrow will be mainly produce a lot of long haul flights.

Birmingham is the most mixed businesses. KPI 130 meals per hour of labour used. So, they want to know why I’m below the KPI.

Different airlines will have different way to work out their labour. Every meal produced is timed, put into a big system that tells u how many meals to produce.

Equipment staff:

Get in basic stuff from warehouse and divide everything into schedule. Dealing with 3 specific airlines. We have to put the trolleys in ...we supply the cutlery, salt and pepper.

We sealed and put them into the fridge.

A stock count every month, the stock take has to email to emirates and they will supply you with the amount you need.
## Appendix 5 Demographics

<table>
<thead>
<tr>
<th>Name of Interviewees</th>
<th>How long have you been working in the flight catering industry?</th>
<th>How many airline companies does your flight unit support?</th>
<th>What is the number of daily flight from your unit?</th>
<th>How many tray sets per day does your unit provide to airlines?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22 years</td>
<td>24 airlines</td>
<td>25 flights</td>
<td>3,000 / 5,000 tray sets</td>
</tr>
<tr>
<td>B</td>
<td>Over 12 years</td>
<td>Over 100 companies</td>
<td>6000 flights a year</td>
<td>4500000 a year</td>
</tr>
<tr>
<td>C</td>
<td>Over 12 years</td>
<td>11 international airlines, 20 domestic airlines</td>
<td>60 flights</td>
<td>6,000-8000 economic class tray sets.</td>
</tr>
<tr>
<td>D</td>
<td>Over 12 years</td>
<td>11 airlines</td>
<td>20,000 main meals</td>
<td>20,000 tray sets</td>
</tr>
<tr>
<td>E</td>
<td>Over 12 years</td>
<td>20 airlines</td>
<td>30 flights</td>
<td>8,000 tray sets</td>
</tr>
<tr>
<td>F</td>
<td>Over 12 years</td>
<td>10 airlines</td>
<td>20 flights</td>
<td>4,400 tray sets</td>
</tr>
<tr>
<td>G</td>
<td>Over 12 years</td>
<td>Low season 7-10, high season 12-18 including 12 charter as well</td>
<td>Low season 8 -12 flights, high season 25 flights</td>
<td>5,000 tray sets (low season 800-1200, high season 3000-5000)</td>
</tr>
<tr>
<td>H</td>
<td>Over 12 years</td>
<td>34 airlines</td>
<td>45 flights</td>
<td>14,000 per day</td>
</tr>
<tr>
<td>I</td>
<td>5-8 years</td>
<td>7-15 airlines</td>
<td>12-27 flights</td>
<td>7,000 per day</td>
</tr>
<tr>
<td>J</td>
<td>9-12 years</td>
<td>98 airlines</td>
<td>77 flights</td>
<td>40,000 per day</td>
</tr>
<tr>
<td>K</td>
<td>Over 12 years</td>
<td>34 airlines</td>
<td>80-210 flights</td>
<td>16,000-65,000 per day</td>
</tr>
</tbody>
</table>
## Appendix 6 Menu /Tray set development and design

<table>
<thead>
<tr>
<th>Name of Interviewees</th>
<th>Who designs menus and menu combinations - the airlines, yourselves, or a combination of the two?</th>
<th>Do you have a team to manage this new product development process? For instance, do you have development chefs or other specialists (nutritionists)?</th>
<th>What is the typical lead time for the development of a new product? Is this the same tray set design?</th>
<th>How do you forecast the number of tray sets to prepare for each flight?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A combination of the two</td>
<td>A special team composes 2 chefs, a doctor in nutrition and a doctor in biology</td>
<td>3 weeks, but for local cuisine production takes 3 days (1 day for ideas, 1 day for cost evaluation, 1 day for chef to prepare the food)</td>
<td>24 hours notice form airline prior to flight departure</td>
</tr>
<tr>
<td>B</td>
<td>A combination of the two</td>
<td>A special team composes 6 chefs</td>
<td>1-2 weeks</td>
<td>24 hrs before departure. Final call from airline companies 4 hrs before flight departs</td>
</tr>
<tr>
<td>C</td>
<td>Only airline companies</td>
<td>A new product development team, no chef or specialist involved</td>
<td>Airline Company decides</td>
<td>24 hrs for preload and 6-12 hrs for final load</td>
</tr>
<tr>
<td>D</td>
<td>A combination of the two</td>
<td>An Executive Chef and some specialists</td>
<td>Depending on whether our Exec. Chef is busy or not</td>
<td>24 hours before get initial meal order. 4 hours before the airline companies update the meal numbers</td>
</tr>
<tr>
<td>E</td>
<td>A combination of the two</td>
<td>A menu development department composes 4 chefs</td>
<td>Local cuisine takes 2 weeks, First/business takes a month</td>
<td>By HACCP system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
| F | A combination of the two | A special team composes chefs and nutritionists | 15 to 20 days | 1) airline inform  
2) based on previous records |
| G | Only airline companies | Two chefs to develop new menu, A nutritionist controls calories  
One local Thai chef | 3 days | 10 % more than reservation |
| H | A combination of the two | A “Product Development Chef” | 2-3 days either in short or long hauls. | Airlines provide the passengers load figures. |
| I | A combination of the two | Don’t have a new product development department  
but have 2 executive chefs | 4-12 days | 1) Orders from airlines  
2) forecast number of tray sets based on routine daily flights |
| J | A combination of the two. Airline companies will provide menu guidelines | Food and beverage department is in charge of new product development | 3 days | 1) Airlines will give 24 hours notice prior to flight departure. 2) another 10% more just in case |
| K | A combination of the two. Catering division provides the suggestions. | No specialised team  
one executive chef and six chefs work on the new product development | 3 days to develop new product, the menu changing cycle is 3 months once for long haul flights | Through daily booking list which is created by reservation system from airline. |
# Appendix 7 Menu / Tray set testing and process engineering

<table>
<thead>
<tr>
<th>Name of Survey</th>
<th>Do you carry out testing of new menus or products?</th>
<th>How do you organise and identify regular meals with special meals, such as MOML (Muslim meals) or SFML (seafood meal), on the same flight?</th>
<th>How do you calculate the amount of materials of food/ingredients necessary to provide the menu for passengers?</th>
<th>How do you do tray sets ups — do you use conveyor belts or work stations or any other method? Why do you use this method?</th>
<th>How do you make sure you have enough galley equipment to set up?</th>
<th>What is your opinion about passengers pre-ordering their meal when booking a ticket?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yes. Passengers involved</td>
<td>Different teams and separated kitchens</td>
<td>Weight multiply by the passenger count</td>
<td>Workstation</td>
<td>Push system running (PSR)</td>
<td>OK. 6hrs notice in advance</td>
</tr>
<tr>
<td>B</td>
<td>Yes. Passengers involved</td>
<td>Different sections</td>
<td>Weight multiply by the passenger count</td>
<td>Workstation</td>
<td>Warehouse check inventory</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>No. People from airlines, doesn’t involve passengers</td>
<td>Different teams</td>
<td>Weight multiply by the passenger count</td>
<td>Workstation, conveyor belts for F/C, B/C</td>
<td>Warehouse check inventory</td>
<td>Not much opinion, 24 hrs notice in advance</td>
</tr>
<tr>
<td>D</td>
<td>No. People from airlines, doesn’t involve passengers</td>
<td>Different teams and separated kitchens</td>
<td>Menu planning system II (MPS II)</td>
<td>Workstation, conveyor belts for F/C, B/C, E/C</td>
<td>Material Handling System (MHS)</td>
<td>1) Services promotion  2) The left meals can left for next flight</td>
</tr>
<tr>
<td>E</td>
<td>No. People from airlines, doesn’t involve passengers</td>
<td>Different teams</td>
<td>Computer system calculation</td>
<td>Workstation, conveyor belts for F/C, B/C</td>
<td>A floating section</td>
<td>Not much opinion depends on cost.</td>
</tr>
<tr>
<td>F</td>
<td>Yes. Passengers involved</td>
<td>The same team prepare but loaded separately</td>
<td>Weight multiply by the passenger count</td>
<td>Workstation, conveyor belts for F/C, B/C</td>
<td>Warehouse check inventories</td>
<td>No individual meal request. Only follow airline’s menu</td>
</tr>
<tr>
<td>G</td>
<td>No. People from airlines, doesn't involve passengers</td>
<td>Different teams</td>
<td>Aircraft configuration.</td>
<td>Workstation for F/C, B/C conveyor belts for E/C</td>
<td>Warehouse check inventory</td>
<td>Good</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------</td>
<td>----------------</td>
<td>------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------</td>
<td>------</td>
</tr>
<tr>
<td>H</td>
<td>It only involves airline executive/representative and product development team.</td>
<td>Identified by means of identification labels</td>
<td>The item list was based on menu specification and on cycle rotation. (either 3 months, 6 months or annual)</td>
<td>90% by conveyor belts for tray setups such as economic class. Work stations are utilised 10% for tray setups in first/business class and crew meals</td>
<td>Equipment allocation list is provided by airlines based on number of frequencies</td>
<td>Good</td>
</tr>
<tr>
<td>I</td>
<td>No. Only airlines are involved.</td>
<td>Have a purchasing system to identify special from regular meals</td>
<td>Food cost, materials of food/ingredients will be listed out in financial control system</td>
<td>All the main courses are produced from work stations and the remaining tray setups and assembly are accomplished by conveyor belts</td>
<td>According to our flights chart schedule.</td>
<td>It's ok but need to co-ordinate with airlines</td>
</tr>
<tr>
<td>J</td>
<td>No. But have survey forms on board and also look at crew feedback</td>
<td>Order from &quot;Special meal booklet&quot; but minimum 24 hrs prior to the passenger's travel. Distinguished by different colour's labels</td>
<td>By judging the configurations of the aircraft and also look up with &quot;passengers book manifest&quot;</td>
<td>Economic and business classes are using conveyor belts. First class employs table setup</td>
<td>Have a system named &quot;Space&quot;, especially for the galley planning and logistic forecast.</td>
<td>It's good and food wastage would be lower.</td>
</tr>
<tr>
<td>K</td>
<td>No. Normally only airlines are involved but sometimes they invite VIP passengers.</td>
<td>They are labelled different colours and stored in a dedicated cart to distinguish them from normal meals</td>
<td>A AS400 system for accurate forecasting of meals, meal planning, invoice and manually account with number of passengers and size of aircraft</td>
<td>Conveyor belts for economic and crew meals. VIP flights, first class and business class employ table process</td>
<td>Manual the aircraft configurations to predict the number of galley equipment and consult the airlines.</td>
<td>Good</td>
</tr>
</tbody>
</table>
## Appendix 8 Flight fulfilment management

<table>
<thead>
<tr>
<th>Name of Survey</th>
<th>How do you control the processes to operate or assemble meal sets for departure on time?</th>
<th>What is the impact on the production operations when passengers choose their meals at the time they book their tickets?</th>
<th>Do you apply JIT in your in-flight operation? If so, in what way and what are the benefits?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Following a production program</td>
<td>Positive attitude. 24 hrs notice in advance</td>
<td>No, we are just a small unit.</td>
</tr>
<tr>
<td>B</td>
<td>Following standard operations management</td>
<td>Positive attitude. Reason: less wastage</td>
<td>Yes, provide passengers fresh products</td>
</tr>
<tr>
<td>C</td>
<td>Following standard operations management</td>
<td>Negative attitude. Reason: costs will increase</td>
<td>No. We don’t.</td>
</tr>
<tr>
<td>D</td>
<td>Following standard operations management</td>
<td>Positive attitude. 24 hours prior to departure time</td>
<td>NO. 1) The meals are hand-made. 2) Each dish changes with cycle changes</td>
</tr>
<tr>
<td>E</td>
<td>HACCP system</td>
<td>Positive attitude. Follow airline company policies</td>
<td>It’s worth to apply. Save cost and time.</td>
</tr>
<tr>
<td>F</td>
<td>Following standard operations management</td>
<td>Negative attitude. Chaos in the kitchen</td>
<td>Do even better than just in time. We should be done before time.</td>
</tr>
<tr>
<td>G</td>
<td>Hazard Analysis and Critical Control Point (HACCP) standard</td>
<td>Positive attitude. Follow airlines demand</td>
<td>It’s good. It can keep food fresh.</td>
</tr>
<tr>
<td>H</td>
<td>Based on flight standard departure time</td>
<td>Don’t foresee any problems as long as 8 hrs production notice in advance.</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>Start to setup trays 8 hrs before departure and airline will telex the final orders to at least 2 hrs before departure</td>
<td>It is not a problem. Depending on the booking time</td>
<td>NO</td>
</tr>
<tr>
<td>J</td>
<td>Through the telex for meal control unit and on the daily movement</td>
<td>Good. As airlines give notice in advance.</td>
<td>NO</td>
</tr>
<tr>
<td>K</td>
<td>By passenger figures. Setup the tray set 8 hrs before departure, assembly 4 hrs before departure and loading meals onboard 2 and a half hours before departure.</td>
<td>It’s good. Accurately predict the amount of materials</td>
<td>NO</td>
</tr>
</tbody>
</table>
Appendix 9 Flight fulfilment realisation

<table>
<thead>
<tr>
<th>Name of Survey</th>
<th>How do you manage flight delays?</th>
<th>Are there occasions when you delay a flight? If so, what causes this?</th>
<th>How do you manage the mix of products – first class, business, economy, etc? Do you produce all in-house or do you outsource?</th>
<th>How do you ensure correct individual demand of passenger? (For example in first class)? What is the rule or standard process to dispatch these meals in your company?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Can manage with the airlines all the strange situations</td>
<td>Never</td>
<td>90% in house, few items we outsource</td>
<td>Ordered before 24 hrs. The procedure is same as other special meals</td>
</tr>
<tr>
<td>B</td>
<td>Follow policy and contract between us and airline companies</td>
<td>Yes, due to traffic jam and bad judgment from assembly workers which leads to insufficient food to supply on board</td>
<td>All in-house. Outsourcing is less because can purchase cheaper stuff</td>
<td>Meet airline companies’ request</td>
</tr>
<tr>
<td>C</td>
<td>Just wait for airline to inform</td>
<td>Yes, due to traffic jam or bad judgment from assembly workers in overlooking the number of trays on board</td>
<td>All in-house except kosher meals</td>
<td>Follow ISO9001.30 mins in advance</td>
</tr>
<tr>
<td>D</td>
<td>All delay reports must be investigated and rectified immediately</td>
<td>Yes, occasionally. We have set 2 hours of cold holding time before loading meals. Most of the delay cases are caused by last minute meal order</td>
<td>Most in-house. Airline requires less purchase</td>
<td>Ordered before 24 hrs. The procedure is same as other special meals</td>
</tr>
<tr>
<td>E</td>
<td>Our unit is close to airport so there is no delay for us to load and unload food</td>
<td>Never</td>
<td>All in-house</td>
<td>HACCP system</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>Transfer from normal flight to the delayed flight and let is go as soon as possible, and then prepare for the normal flight.</td>
<td>No delay cause by caterer in last 35 years</td>
<td>All in-house. Cheap and abundant manpower, material and machinery is available in India</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>Swap the menu depending on delayed meal times</td>
<td>Yes. Assembly workers’ underestimate occasionally cause shortage of food</td>
<td>All in-house</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>Meal prepared on day to day and flight to flight basis. The meals will be unloaded and thrown away if already loaded on the delayed aircraft except non-perishable items</td>
<td>Shortage of loading bays or high loaders during peak period are chances of delays.</td>
<td>First/business classes are prepared by 1 lot of stall. Economic class and crew meals are prepared by another lot of stall. All produced in-house.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Account for buffer meals in case of flight delays.</td>
<td>Airlines sometimes have last minute orders or special meals which caused the flight to be delayed.</td>
<td>We have designated working area for first, business and economy class to separate them. All done in-house.</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>Below 5°C loaded food may be kept on board for up to 12 hours. In consultation with duty catering order and contractor after 4 hours and at 4 hours interval</td>
<td>Miss-communication and shortage in items due to human errors.</td>
<td>All done in house.</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>Render the loaded meals as wastage and not use them</td>
<td>Meals are missed out by workers</td>
<td>All done in house.</td>
</tr>
</tbody>
</table>
Appendix 10 Published article of MC Mode in Flight Catering

INVESTIGATION OF MASS CUSTOMISATION MODE IN FLIGHT CATERING OPERATIONS

Yevvon Yi-Chi Chang
University of Surrey
Guildford, Surrey, UK

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Guildford, Surrey, UK

and

Li-Jen Jessica Hwang
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Guildford, Surrey, UK

ABSTRACT

Mass customisation (MC) is a manufacturing strategy that enables high volume production at low unit cost, while providing relatively customised or personalised products or services. The flight catering industry is beset with the problem of coping with high volume and variety. In this study, we investigate for the first time, the existence of MC in flight catering operations. In particular the specific MC mode adopted by this industry is identified in relation to the five alternative modes proposed by MacCarthy et al. (2003). This study concludes that flight catering engages in ‘flexible resource call-off’ MC.

Key Words: Flight Catering; Operations Management; Mass Customisation.

INTRODUCTION

In recent years, the flight catering industry has undergone a revolution in response to the changing nature of flight travelling business, due to a significant shift industry concentration and growth of low cost airlines (IATA, 2005). Flight caterers face the pressure of lowering their product prices to meet the demands of airlines without compromising quality of their products. To stay ahead in this competitive environment, many flight caterers not only have to provide bulk volume of meals but also have to constantly develop new menus and dishes to appeal to airline passengers. The flight catering industry is thus, faced with the dilemma of coping with high variety of products while operating at high volume.

Mass customization (MC) has been identified as the synthesis of two alternative approaches to production, namely job shop and assembly line (Brown et al., 2000). MC enables the high volume production of a wide variety of products by adopting a range of policies, procedures and techniques in relation to the supply chain, production design, and order fulfillment processes (Gilmore and Pine, 1997). The flight catering industry has been selected for this investigation because there is an a priori case that typical flight kitchens engage in MC due to their high daily outputs and great variety between airlines, seat classes and day parts.

Apart from exploring the concept of MC, the main purpose of this paper is to investigate to what extent MC exists in flight catering industry, with the intention of matching flight catering operation to the fundamental MC modes of operations proposed by MacCarthy et al. (2003). By comparing the elements in the aforementioned MC model with current operational processes of the flight catering industry, a MC mode can be identified. Hence, this paper seeks to determine the MC mode of current flight catering practices to further facilitate a more in-depth and detailed study of operational processes in this industry.

THE FLIGHT CATERING INDUSTRY

A single flight by a long-haul Boeing 747 (the ‘jumbo jet’) may require over 40,000 separate items loaded onto it. Flight caterers at major hubs, such as London Heathrow, Frankfurt and Atlanta may be handling twenty or more Boeing 747s, as well as many smaller flight carriers per day. Therefore, it is very clear that flight caterers handle a considerable volume of products on a daily basis (McCool, 1996; Jones, 2004). In essence, airlines require caterers to provide all meals, beverages, and perhaps other products such as paper goods, blankets, magazines, headsets and amenity kits. The items for consumption during the meal may include snacks, confectionary, breads, appetizers, meats,
vegetables, desserts, salads, cheeses, soft drinks, beers, wines and spirits (Tabachi and Marshall, 1988). Although referred to as ‘flight kitchens’, the food production part of the operation is relatively small. The focus of attention is on assembly – dish assembly (assembling hot entrees and other dishes from their components such as meat, meat fish, rice, and assorted vegetables); tray assembly; bar cart assembly; and trolley loading.

On most scheduled airlines, there is more than one seat class, and for long haul flights there is more than one meal for each passenger. In addition, airlines operate menu cycles or ‘rotations’ to ensure that frequent flyers are not always served the same menu. Moreover, most airlines cater for specific dietary needs of passengers that result from religious persuasion or medical conditions. Typically, a flight caterer may have to offer more than 26 different types of ‘special meal’, such as kosher, halal, low-fat, low-salt and vegetarian. In addition, crew meals are required for safety reasons to be different from passenger meals, and the crews are engaged in active work and require higher energy intake (McCool, 1995; Jones, 2004). Thus, even within one airline there exists a wide variety of menus and meals.

Most flight caterers contract to supply more than just one airline, as there are few airports where a single airline has enough flights to justify the exclusive use of a kitchen, except for the ‘hub’ airports of major carriers. So within the flight catering business, there are considerable varieties of outputs to cope with, deriving from:

- Number of airlines
- Types of airline – scheduled, charter, low-cost, executive
- Duration of flight – short haul, long haul
- Seat class – first, business, economy, and chatter flight.
- “Day –part” – breakfast, mid-morning, lunch, mid afternoon, dinner
- Demand for special meals

MASS CUSTOMISATION

As pointed out, the flight catering industry has the characteristics of high volume and high variety. Hayes and Wheelwright (1979) explained the trade-offs between five different manufacturing processes that can produce different levels of variety and volume. Job shop, for example, can produce wide variety of products but can only produce them in low volume. In contrast, mass production can produce large quantities of products but only offers low variety. Schmenner and Swink (1998) further described that the phenomenon of cross-factory productivity differences can be explained by the Theory of Swift, Even Flow. This theory illustrated that productivity decreases as variety of products/services increases. An extension to Hayes and Wheelwright’s (1979) typology has been the inclusion of MC, as shown in Figure 1. MC is a synthesis between job shop and assembly line (Brown et al., 2000). Consequently, MC lies in the position where high volume is achievable while having to cope with variety. How it does this is explained in the next section.

![Figure 1](image-url)

In order to identify the scope of MC and the range of operations that qualify as MC, MacCarthy et al. (2003) analysed the six alternative classification schemes of MC (Lampel and Mintzberg, 1996; Ross, 1996; Gilmore and Pine, 1997; Alford et al., 2000; Duray et al., 2000; Da Silveira et al., 2001) and applied them to five case studies - National Bicycle Industrial Company, Motorola bandit pagers,
European bicycle manufacturer, Computer assembler, Commercial vehicle manufacturer. However, they found that these existing classification schemes could not clearly distinguish between their selected cases and hence did not differentiate the key characteristics of MC. Therefore MacCarthy et al. (2003) identified these important distinguishing factors and used them to develop their own typology of fundamental modes of MC. Their basic model of manufacturing has six operations processes that are fundamental to MC: order taking and co-ordination, product development and design, product validation and manufacturing engineering, order fulfillment management, order fulfillment realisation and post-order process (Figure 2).

![Figure 2](image)

**Figure 2**

Operations processes in a MC system

(MacCarthy et al., 2003:296)

MacCarthy et al (2003) go on to identify that there are alternative ways of executing some of these processes. These relate to whether the product design and validation/manufacturing engineering is by per order or by per product, the order is by once off or by call-off, the order fulfilment activity is fixed or modifiable. As a result, these alternative permutations lead to five fundamental operational models for MC, as illustrated in Figure 3 and the different MC modes are described respectively below:

![Figure 3](image)

**Figure 3**

The Five Fundamental MC Modes

(MacCarthy et al., 2003:298)

**Mode A – Catalogue MC**: A customer request is fulfilled from a pre-designed catalogue of selections produced using standard order fulfillment procedures. In this mode, the engineering of products is not correlated to requests but are completed even before requests are taken. Customers select from a pre-specified choice and products are assembled by order completion activities that are already in place. Similarly, the order fulfilment activities are engineered prior to an order being received. Industries categorised by MacCarthy et al. (2003) under this mode include: National Bicycle Industrial Company, Motorola bandit pagers, Computer assembler and Commercial vehicle. For instance, a computer assembler allows customers to configure by means of a catalogue their own desired computers.

**Mode B – Fixed resource design-per-order**: In this case, a customer request is satisfied by producing a customer specific product, created through standard order fulfilment processes. The customer places an order for the product but no repeat orders are anticipated. In this mode, there is some
degree of product engineering for both the customer and the manufacturer/service provider, unless a customer's need happens to match a previous order, in which case the product design is recycled. Adidas shoe manufacturer has a concept that allows customers to customise their own designs. We suggest the classification of Adidas to be under Mode B where the order fulfilment processes are standard throughout and normally, no repeat orders are expected from the same customer.

Mode C – Flexible resource design-per-order: Here, a customer request is also completed by manufacturing a customer specific product, but produced through modified order fulfilment procedures, where a new supplier or sub-contractor is engaged to facilitate the production of the customised product. The customer requests for a product and there is no expectation of repeat orders. In this mode, products are produced per order and the order fulfilment process may be personalised per order. Under the classification of this mode, we recommend Swatch watch company. Swatch has an online concept (Swatch Via Della Spiga) that allows customers to design and match their own desired requirements. Customers' orders are expected to be per order and the order fulfilment processes are modifiable.

Mode D – Fixed resource call-off MC: In this mode, a tailored product is designed for a customer, to be made via standard order fulfilment processes in expectancy of repeat orders. At the prompting of a customer, a product is designed and manufactured through the standard order fulfilment process, whereby customer's choice is limited by the capabilities of manufacturer's/service provider's existing order fulfilment resources. The European bicycle company falls in this category; hence the customer can order the same bicycle model again, any time in the future.

Mode E – Flexible resource call-off MC: This mode is similar to Mode D except for the fact that order completion activities are modifiable. A customer request is met by engineering a customer specific product, which is produced through made to order fulfilment processes, whereby a manufacturer/service provider is prepared to vary its order fulfilment resources by outsourcing to new suppliers. In this case, for instance, in a Commercial vehicle manufacturing industry, there is the possibility of repeat orders.

RESEARCH DESIGN AND METHODOLOGY

The purpose of the study reported here is to identify which of these modes is relevant to the flight catering industry. The nature of this study was exploratory and was conducted through a qualitative research design. Data was collected from three alternative sources in order to provide 'triangulation' of data. Denzin (1989) defined triangulation as the combination of methodologies to study or research the same phenomenon. Triangulation is regarded as a strategy to overcome problems of validity and bias (Patton 1990; Mason 1996; Arksey and Knight 1999). A triangulated approach facilitates the cross checking of results by using different methods. The first source was secondary data, principally a recently published textbook (Jones, 2004), as well as trade publications. The second source of data derived from observational studies of six flight kitchens in United Kingdom (UK). The third data set was obtained through structured interviews with flight catering managers that had knowledge of the operational process in the industry. Hence, validity is ensured throughout the investigation in this study. Based on observational findings, factors that were relevant to the study were identified so that the structured interviews could be conducted in order to confirm or otherwise secondary and observational findings.

The preliminary fieldwork began with unstructured observations based on visits to six flight catering companies in the United Kingdom (UK). From initial observations, a grasp on the general idea of the operation processes in the in-flight catering industry was achieved. Further visits to these flight kitchens provided a clearer understanding of the processes and knowledge for the identification of factors that may be relevant to the aims of this study. The main objective was to identify if McCarthy et al.'s (2003) six processes namely, product design/development, product validation and manufacturing engineering, and order fulfillment realisation vary for different modes while the other three processes (order taking/co-ordination, order fulfillment management and post order process) could be identified in this context. A second objective was to identify the terminology used in this context for these six activities, as almost certainly flight catering professionals would not use the same terminology as McCarthy et al. (2003). This ensured that the interview incorporated terminology and phraseology that respondents would be familiar with.

For the interviews, quota sampling was used (Oppenheim, 1996). Respondents who were in the best position to provide the information required were identified. Specifically, the targets for sampling
were professionals, who were senior managers who have in-depth knowledge of operational process in the flight catering business. Caterers servicing short and long haul flights were chosen because they were inherently offer more diverse product range. Non-UK based respondents were also selected in order to ensure that the practices identified through field visits were not unique to the UK. Eleven in-depth interviews were conducted at the IFCA trade show, which was held in Nice, France in February 2004. The International Flight (from March 2005 now Travel) Catering Association is a professional association serving the needs of all member companies in the industry - scheduled and charter carriers, specialist catering companies, and supplier companies of equipment, food and beverages. IFCA held its first conference and trade show in 1982 and has continued this annually ever since - usually in a different European location each year, and attended by well over 1,000 delegates. To achieve reliability, questions were carefully piloted and developed to eliminate respondents' biases. In addition, interviews were recorded using a voice recording device to avoid bias.

From the gathered primary data, content analysis was carried out to interpret the operational processes in relation to the flight catering industry. According to Neuendorf (2002:36), content analysis is "a technique which aims at describing, with optimum objectivity, precision and generality, what is said on a given subject in a given place at a given time". Applied strength of Content analysis gives rise to a systematic, repeatable method for the identification of contents from texts or words that leads to the deduction of inferences for a particular investigation or study (Berelson, 1952; Krippendorff, 1980 and Weber, 1990). At a broader level of definition, Holsti (1969:14) stated that content analysis is 'a technique that makes inferences by objectively and systematically identifying specified characteristics of messages'. Babbie (2002) defines content analysis is a no-obtrusive research meaning the researcher does not influence the subject to determine his motivation or responses. Instead, the researcher codes the raw data which can be texts, messages or images to gain insights on social processes.

**FINDINGS**

In this study, the operational processes of the flight catering industry were compared with MacCarthy et al.'s (2003) MC modes. Three processes namely, product design/development, product validation and manufacturing engineering, and order fulfilment realisation vary for different modes while the other three processes (order taking/co-ordination, order fulfilment management and post order process) are fixed for all modes. From the observational study, all six processes could be identified. The focus of the interviews was to investigate in particular the three processes that vary, so that the specific mode of MC could be identified. Although all the respondents surveyed were located in different parts of the world (Asia, Middle East and Italy), they all implied there is a commonality in this industry. First, all the companies showed they have to cope with large volumes, between 3000 and 8000 meals each day. At the same time, they all had to serve several airline companies 20-30 flights daily.

Starting with the product design process, respondents reported that they present airline companies with a list of different food items for them to form in order to develop menus. All respondents employed the services of professionals (chefs and nutritionists) or even a dedicated team to handle the design of new menus or products at the request of airline companies. Most suggested the typical lead time from design to production of a new menu or product took about 1-2 weeks. Typically when a new menu or product was created, caterers invited airline companies, and some invited passengers, to test the new product. Feedback from airline companies and passengers were noted and then modifications were made if necessary. At the process engineering stage, a certain set of manufacturing procedures and rules had to be enforced to ensure that the same product can be manufactured again and again. Some caterers employed ISO9001 to standardize their processes. In a typical manufacturing environment, bill of materials are generated along with guidelines on routing and processing instructions. Regarding the generation of bill of materials, the commonly used method to estimate the amount of food/ingredients necessary to provide enough meals for a flight was calculated by multiplying the weight of ingredients with passenger counts. Some caterers had computer assisted systems and one relied on the size of aircrafts to estimate the amount.

Once the amount of raw materials to provide for a certain flight was known, the next step was to assemble the different food items such as, salads, biscuits and butter onto the tray. This process was facilitated with the use of conveyor belts or workstation. In an economy class, the variety of meals to choose from is very limited and needs to be served in large volumes. Therefore, conveyor belts were used for the production of economy class meals in large volumes. For first and business classes, workstations were utilised. To ensure safe dispatch of meals to passengers, procedures and systems such as, Hazard
Appendices

Analysis and Critical Control Point (HACCP) system were in place. Before meals could be served, there must be enough galley equipment to set up trays for passengers on board. Methods like Push system running (PSR), Material Handling System (MHS) and warehouse inventory stock check ensured that caterers provided enough galley equipment to set up trays for passengers.

Regarding the question on the forecast of number of tray sets to prepare for each flight, some caterers replied they preload 24 hours before departure and a final load was performed 4-6 hours before flight departure. Some had accounted 10% more on top of their estimated tray sets indicated by their reservation systems. All respondents identified they followed a standard operational management protocol to control their processes so that meals are delivered on time. HACCP mentioned earlier is one of the two operational standards companies employed to control the processes needed to operate or assemble meal sets for delivery of meals to flights on time. Other companies applied Just-In-Time (JIT) in their flight catering operations. All the caterers interviewed had strategies to manage flight delays. Sometimes flight delays were due to air traffic congestion and bad judgment from assembly workers which then led to error in predicting the correct amount of food onboard. Some had buffer meals to curb with the shortfall in meal sets. One caterer suggested setting 2 hours of cold holding time before loading meals to keep the food fresh. Investigations of flight delay issues were immediately followed up and rectified. Managing flight delays such as the use of buffer meals to make up the necessary amount suggested that the companies were flexible in their allocation of resources in the event of flight delays.

DISCUSSION

McCarthy et al. (2003) identify that order taking and co-ordination is always per order (refer to Figure 3). Our research findings showed that in flight catering, contracts are signed for a period of typically three years and orders are placed on a flight by flight basis. Product development and design is achieved in three alternative ways, by pre order or per order or per product/pre order, as shown in Figure 3. According to MacCarthy et al. (2003) pre order refers to design of the product takes place prior to any orders being made; per order means that the customer is involved during each order fulfillment cycle, so, the customer's product is designed and engineered between order taking and delivery; whilst per product family refers to design processes that are completed before any customer places an order for a product. The findings identified that caterers provide a range of food items for airline companies to choose and form their desired menus. However, if airline companies desired special menus that could not be realised from pre-fabricated list of food items, a dedicated team that comprised of nutritionalists and chefs, formed by caterers will handle such requests. As such, the process of design and development of menus is classified as per product/pre order since caterers provide a wide range of specific food items for airline companies to choose from and design their own menus.

The three alternatives - pre order or per order or per product/pre order - also apply to product validation and manufacturing engineering. With regard to the product validation and manufacturing engineering process, findings showed that flight catering companies had computer assisted systems and set of manufacturing rules and procedures to ensure the manufacturability of product design. Assembly of materials required for production of meals were completed before customers' orders are placed. Hence, tray service is classified to operate on a per product basis. In addition, meals can be repeated to meet customers' demand. The order fulfillment management process is always per order. Hence flight kitchens begin to assemble meals, trays and trollies in response to the established schedule of flights they have to service. The order fulfillment management involved the airline companies throughout because airline companies would provide caterers with the forecast of meals to supply. The final number of meals would be informed via fax or telephone to caterers 4 to 6 hours before flight departure. Therefore, the order fulfillment management is classified as per order.

McCarthy et al (2003) suggest that order fulfillment realization may be either fixed or modifiable. The difference between fixed and modified order fulfillment resource is that they can fulfill within their present materials supply, processing and delivery resources or they can modify them. Investing in additional or different process technology or engaging a new supplier or subcontractor so as to enable the manufacture of customised products all belonged to modified scope. The findings identified outsourcing of products (special meals), flexible allocation in resources (buffer meals in the event of flight delays) and delivery modes (special meals are separated from normal meals) showed that the order fulfillment realisation is modifiable. The post-order process is per order. Caterers invoice airlines on a flight by flight basis and respond to customer complaints, cabin crew feedback and other enquiries on this
basis too. Table 1 summarises the temporal relationships between the different operational processes in mode E.

<table>
<thead>
<tr>
<th>Table 1 Classification of Mass Customisation Mode in the Flight Catering Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Processes</strong></td>
</tr>
<tr>
<td>Order taking/co-ordination</td>
</tr>
<tr>
<td>Product development and design</td>
</tr>
<tr>
<td>Product validation and manufacturing engineering</td>
</tr>
<tr>
<td>Order fulfillment management</td>
</tr>
<tr>
<td>Order fulfillment realisation</td>
</tr>
<tr>
<td>Post order processes</td>
</tr>
</tbody>
</table>

(Adopted from MacCarthy et al., 2003:299)

From the analysis discussed above, two operational modes of MC proposed by MacCarthy et al. (2003) that closely matched the operation processes of the flight catering industry were identified - modes D and E. Both modes are very similar in every aspect with the exception of order fulfillment realisation where it is modifiable in mode E while fixed in mode D. The order fulfillment process of the flight catering industry was gathered to be flexible as mentioned earlier. Hence, the flight catering industry is categorised under mode E.

CONCLUSION

The flight catering industry has to constantly cope with both high volume and variety. Everyday, high volume of meals are transacted in this business that need to serve different airlines. As a result, compromises in products or services may have resulted. The concept of MC allows high volume and high variety to be achieved while no trade-offs are necessary. To date, there are no existing published articles pertaining to MC in the flight catering business. This study therefore investigated and determined that MC does exist in current flight catering operations. Further, the flight catering industry was categorised to be ‘flexible resource call-off MC’, by comparing elements in the MC model proposed by MacCarthy et al. (2003) with current operational processes observed and reported on in flight catering operations. Having established the mode of MC, the research project is ongoing in order to identify the precise MC policies and procedures that flight kitchens have adopted to achieve efficient operation.

REFERENCES


Appendices

Appendix 11 The cover letter and survey form for collecting data

For the attention of: General Manager / Operation Production Manager

RE: Flight Catering Research Study

Dear Sir/Madam,

My name is Yevvon Chang and I am a PhD researcher in the School of Management at the University of Surrey. Prof. Peter Jones is my supervisor and the current IFCA (International Flight Catering Association) Professor. I am conducting a study on the operations processes of flight catering units and I would greatly appreciate if you can assist us with our study.

The purpose of the study is to try to understand the relationship between operating variables such as total output and meal output, number of airlines and number of flights, staffing and building size. (please complete the attached Table)

We appreciate your annual performance may be confidential which is why are only asking about one specific week (the last full week in October 2004). We acknowledge this may not be typical for your unit and will make no assumption about your average performance. If some of the data is difficult to give an exact value, you can always provide an approximation.
All the information you provide will be treated confidentially. Please email me if you have any questions about the study.
Yours sincerely,

Yevvon Chang
PhD Researcher
Email: y.chang@surrey.ac.uk

Please return the completed table to Yevvon Chang at: y.chang@surrey.ac.uk or alternatively fax back at this no.: +44-1483 686346

**Weekly Data of last week** in October 2004

<table>
<thead>
<tr>
<th>Company:</th>
<th>Unit Name:</th>
<th>24th – 30th October 2004 (inclusive)</th>
<th>Remarks (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total number of tray sets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Total number of hot meals produced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Number of charter airline meals (if applicable)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Number of first and business class meals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Number of airlines served</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Average number of flights served</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Total number of full time employees in the unit.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Number of full time employees in food production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Total number of labour hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Number of labour hours on tray setup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Number of labour hours for hot food production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Size of production unit (total floor area in m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you for your time!
For the attention of: General Manager/Operation Production Manager

RE: Research on Efficiency of Flight Catering Industry

Dear Sir/Madam,

As you are aware, I have previously sent a survey table for the study on improving operational processes efficiency. I do appreciate if you can spend 5 minutes to complete the attached table below. If you have any quires about this study, please do not hesitate to contact me.

Thank you for your contribution!

Yevvnon Chang
PhD Researcher
Email: y.chang@surrey.ac.uk
Please return the completed table to Yevvon Chang at: y.chang@surrey.ac.uk or alternatively fax back at this no.: + 44–(0) 1483 686346

**Weekly Data of last week** in October 2004

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<tr>
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</tr>
<tr>
<td></td>
<td>4. Number of first and business class meals</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>12. Size of production unit (total floor area in m²)</td>
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Thank you for your time!
### Appendix 13 DEA efficiency scores for 19 units

<table>
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<tr>
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<td>3.27 Gategourmet Norway a/s BGO</td>
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<td>5.5 Abela Airport Services Abda-S</td>
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<td>8.10 Airest Catering Postfach Flug</td>
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<tr>
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<td>10.4 Kansai In-Flight Catering Osaka</td>
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<tr>
<td>11.2.6 Gategourmet USAS Istanbul Tu</td>
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<td>12.1.5 Alpha Flight Services LHR Ai</td>
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<td>13.2.3 Gategourmet GmbH Catering Zu</td>
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Appendix 14 Mann Whitney U statistical test of outputs and size of full time employees

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<td>No. of airlines served</td>
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<td>5178.00</td>
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Test Statistics\(^a\)

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\(^a\) Grouping Variable: No. of full time employees

Appendix 15 Mann Whitney U statistical test of outputs and size of building

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<th>Ranks</th>
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<td>Average flights per week</td>
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<td>No. of airlines served</td>
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### Test Statistics$^a$

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$^a$ Grouping Variable: Building size
Appendix 16 Description of each individual case study report

A Case Study on Flight Catering Company A

By Yevvon Yi-Chi Chang
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The author would like to thank all Flight Catering Company A staff for their help, in particular, Gerry Delaney, Ramon Knaven and Jan Nieuwenhuizen. All errors and omissions remain the responsibility of the author.
1. Company Background

The conglomerate group, where Flight Catering Company A is under one of its smaller division served over 100 airlines at 62 airports in 8 countries that spanned across 4 continents: UK, Continental Europe, USA, Middle East and Australia. The company comprised of three divisions: The airport catering division consisted of 28 restaurants and bars at 7 airports in the UK. The retail service division had an extensive range of shopping outlets at 20 UK airports and 80 shops in 4 overseas location, that included Duty and Tax-free shops. Lastly, the flight catering group, which Flight Catering Company A is directly under, operated 32 flight kitchens at 27 airports in the UK, as well as kitchens in Amsterdam and Orlando, USA.

In Amsterdam (Holland), Flight Catering Company A had a catering service unit situated about 7 miles away from Schiphol International Airport. The day-to-day function of Flight Catering Company A was to provide catering services to a mixture of long and short haul airlines arriving and departing at Schiphol International Airport. As 20 of June 2005, the unit served a total of 13 long haul and short haul airlines of which; Japan Airlines (JAL), Cathay Pacific Airway (CX), Singapore Airlines (SI), United Airlines (UA) and Continental Airlines (CO) were their major customers. Flight Catering Company A occupied a floor space of 8000 m² (see Figure 1) which had a capacity in excess of producing 41,000 meals per week, including the increased number of meals for holiday-makers during peak seasons.
Figure 1 Plant layout of Flight Catering Company A
2. Descriptive Case Study of Operational Processes

2.1 Two Key Performance Indicators of Management
To ensure good performance and standard, the management in Flight Catering Company A set certain key performance indicators (KPIs) for each department to follow. The KPIs were meals per hour for the hot food production, tray setups per hour for the assembly department and trays per hour for the washing department. Their Internal Process manager, Roman, explained in greater details, how the meals per hour KPI was obtained:

For instance, at this moment we are looking at daily and weekly operation reports. As you can see, in week 22, we used a total of 5601 hours in that week. If you divide this amount of hours by the total meals sold, you can get our KPI. So this KPI value indicates the target we must achieve for this week or the next week, it’s always 2 weeks of KPI planning in advance. Roughly, this KPI value is 10 completed meals in total per person per hour. For the E/C class, each staff has to achieve 55 tray setups per hour. In the washing area, it is 65 trays per person per hour. We always give the targeted KPI value to the production line first. Like on Monday I’ll give the KPI to the production line for this week’s production. At this moment, the KPI is set by me and I will make plans so I know how many meals we need to produce per day.

Figure 2 Daily weekly operations report
2.2 Functional Flexibility and Temporal Flexibility

By 20 June 2005, Flight Catering Company A employed a total of 141 staff. The working hours varied for each department based on schedules generated by the operation department. For instance, first and business class food assembly was divided into 2 shifts. The first shift began at 06:00 and finished at 15:00, while the other started from 14:00 till 23:00. Economy class food assembly was divided into 3 shifts. One shift started from 06:00 and finished at 15:00, the second from 07:00 to 16:00, and the last shift from 12:00 to 21:00. The working hours in Flight Catering Company A were an average of 9 hours per day, which included a 30 minutes lunch break. On the other hand, there were 2 shifts for the hot kitchen: one from 06:00 to 15:00 and the other from 12:00 to 21:00; in order to produce high quality food by ensuring freshness rather than food items being pre-cooked and stored for a few days. Hence, all business class meals were cooked half-day in advance prior to flight departure. At the time of the audit in 20 June 2005, JAL (Japanese Airline) was Flight Catering Company A’s largest customer. In order to meet their specific requests and standards, Flight Catering Company A not only set up a special kitchen and production line area, but also recruited two Japanese chefs to produce the various products for the taste of Japanese customers.

Flexibility was clearly exhibited in Flight Catering Company A. During seasonal peaks such as summer and Christmas holidays, the company recruited temporary employees to supplement a smaller core of full time employees, thereby increased the productivity to meet the rise in demand.

To ensure that all staff gave their best towards achieving the company’s long and short-term objectives, Flight Catering Company A provided 2-3 days training which consisted of an induction course, hygiene course, fire safety, and comprehensive training in safety compliance. Once the employee was assigned to work in a particular department, he/she would be given on the job training. Furthermore, Flight Catering Company A would occasionally provide specific training courses. For example, the hot kitchen department would provide training courses for chefs whenever airline companies changed their menus.

In Flight Catering Company A, the workers were shuffled daily to work on different flight schedules. However, not all workers could be shuffled to take on the different
tasks. For instance, chefs required a special technical skill, so they would not take any economy class worker and put them into the hot kitchen. The internal process manager, Roman, further explained:

We shuffle the different flight schedules daily for our workers and based on the same process they are in. For instance, F/C and B/C class workers require more skills, so E/C workers only can cover E/C assembly when there is a shortage of workforce but not F/C and B/C class related works. As I mentioned before, JAL is our largest customer and the tray setup is more complex than the other airlines, plus they are produced on the same day of flight departure. So, we sometimes need more staff to cover it especially when the flight is fully booked. This is when we shuffle our staff to cope with the shortage in manpower.

2.3 Information Technology Implementation of Material Requirement Planning

The communication medium between flight caterers and airline companies becomes a significant tool to fight time and money with other competitors in this business. In Flight Catering Company A, they implemented a computer system to assist them in building airline schedules, in order to forecast the quantities of meals required. This Flight Catering Management System (FCMS) was known as the ‘Internal Inventory System’ in Flight Catering Company A. Orders were planned in advance, via materials requirement planning using the ‘Internal Inventory System’ to eliminate unnecessary waste. The forecast of the quantities required for certain ingredients, was first achieved by stating the menu specification agreed with the airline company; which then allowed the requirement for raw materials and ingredients to be estimated. Within the menu specification, there were details containing meal description, menu rotation, product code, entrée and recipe. The standard recipe was an essential component in flight food production. As an example, a vegetarian entrée for Singapore Airlines, Asian Business class, comprised of: 140 g of Indian scramble egg, 40g of mushrooms and 1/2 potato. Hence, if a flight had 10 passengers, Flight Catering Company A then needed to place an order for 1400g (140g x 10) of scramble egg and 400g (40g x 10) of mushrooms. The combination of flight schedule knowledge and recipe detail was the advanced information for input into Flight
Catering Company A’s ‘Internal Inventory System’ to forecast and reduce inventory stock. (see Figure 3)

**Figure 3 Menu specifications**

The implementation of MRP indicated that Flight Catering Company A used a Pull-system instead of a Push-system. Traditional manufacturing plants uses a push system where production schedules are developed for maximum capacity based on sales forecast pushing materials downstream. The inbound logistics manager, Jan, explained how forecasting was performed with the help of their ‘Internal Inventory System’:

*Let's take Singapore Airlines for an example to show you how I forecast the requirements from our internal inventory system. I enter all the milk which we are going to provide with the maximum load, and then I can run a report that tells me how much of each item I need on a daily base maximum from a certain supplier (see Figure 4). So, every supplier that is involved in a Singapore flight is in this report and for example here, it shows me I need a maximum of 2 bottles of sweet chilly sauce per day for this flight. For lemon wedges, the maximum load is 1 and somewhere in this report tells me how many lemons we have to order for Singapore Airline per day.*
For the very complicated and expensive products, I created this file. The diary cheese is very expensive and meat is very expensive too. We cannot afford to have any waste on those items. I translated that, so every month I’m updating this file and next week I am going to update because at the end of this month, Singapore Airline is changing cycle which means that the meat is going to change, the cheese is going to change and bread may change too. Then I’m going to all update it and let my people know that I do not need chicken anymore and now need lamb or whatever. Ok, let me show you how I update our internal inventory system. For instance, when Singapore Airline menu changes next month, this is the list that I am going to update. This column, says for instance, they don’t need 150 grams of cheese a day anymore, so I’m going to put this as nil and I’m going to update this. Next, as you can see here, I need 3155 portions of butter in total on a Friday. So, I have to make sure that I have for the butter; 10.6 crates of 1000 pieces each because it has to last me until Tuesday, so 3000, 2400, 2500 and 3000, if I add these up in total, it’s about 11000 you see. Then, if I go into my chiller and I see there are 4 crates standing, I just order 7 and then I know have enough. Then on Monday morning, I go in again, and then I see maybe there are still 2 crates left because the flights may not be completely full, then I just have to order 6 more. So, this is what I update at the end of the cycle and then it automatically generates the total amount per product per day and that generates me my order list.

This was how the purchasing forecast was planned which helped them minimized any waste. Therefore, the ‘Internal Inventory System’ was an essential tool that not only
Flight Catering Company A Descriptive Case Study of Operational Processes

Aided them in planning forecasts but also in placing orders with suppliers based on the forecasted data.

Figure 5 showed the work flow of Flight Catering Company A, where the operation department was the first point of contact and information was disseminated from there to other departments. The function of the operation department was to handle operation changes, live operations, off schedule flights, flight diversions and also accept passenger figures on a daily basis.

**Figure 5 Work flow of Flight Catering Company A**
Hence, the operation department knew how many meals to produce for each flight. They generated figures pertaining to information that included the number of meals to be produced (crew, passenger and special meals) and flight schedules (estimated arrival and departure time).

**Figure 6 Fight passenger figure from operations department**

2.4 Goods Inward

In Flight Catering Company A, there were 35 suppliers who supplied the necessary ingredients and materials. Delivery of goods was continuous from morning till evening (06:00 to 21:00). Goods received documents were passed to the stores team who then checked for all items arriving at the unit. From what was observed in the store, it was obvious that Flight Catering Company A had good forecasting practices because they did not keep a lot of stocks; as the inbound logistic manager supplier manager, Jan further advocated:

*For the dry goods, depending on the supplier, in general we have between 7 to 10 days of stock because most of our suppliers come once a week. There are 1 or 2 suppliers which we have a minimum order for this amount of pellets or boxes and we have to order every 2 or 3 weeks. So, for a particular item, the stock is a bit higher. For instance, these items are our ambient (ambient describes a product that you can store without chilling or frozen) sauces, base sauces (hot kitchens uses). So, normally, our suppliers come once a week. For some dry goods, some suppliers come every 2 weeks but that’s just one or two. Food like raw meat comes in 3 to 4 times a week. They come in every Monday, Tuesday, Thursday and Friday. Fresh vegetables come in twice a day except on Sunday,*
because there is no delivery whatsoever on a Sunday, so that makes it more fresh, there will be no over production.

Besides the obvious check of product type and quantity, the stores team would also check for quality and for chilled items. In addition, they checked on the temperature of the items that arrived into the store. Any items that failed to reach the agreed standards or were not within the correct temperature guidelines were rejected and returned to the supplier. The storeman then separated the goods accordingly: dry items; wet items; frozen items. On the day of audit, 128 dry items were received. In total, there were 700 different dry items and 200 different chilled items (see Figure 7).

**Figure 7 Items in store**

In addition to different classifications of food items, items for the same flight schedule were labelled for easy identification when collected by other departments for processing. Different coloured stickers were used to assist staff in identifying which day the product was made. Blue was for Friday, yellow for Saturday, brown for Sunday, white for Monday, red for Tuesday, black for Wednesday and green for Thursday. The rationale for this classification was not only for easier identification, but also to facilitate the implementation of 'first in first out' concept. Hence, based on this concept, if there were two same items but one arrived in store earlier than the other, the item with the longer storage period would be utilised first. In essence, the implementation of this concept allowed food items to be used within their expiry dates and in turn, reduced any waste that arose from expired food items.

### 2.5 Food Production

The main workforce in the hot kitchen consisted of 4 chefs and 8 junior chefs. In the hot kitchen, there were 10 large scale hardware equipment which included: deep fat
fryer x 1, grill x 1, steam with wok (two in one function) x 2, western wok x 1, Chinese wok x 1, small oven with steam (two in one function) x 2, big size of oven with steam (two in one function) x 1, stove (gas) x 1 and bread oven x 1. All these equipment were commonly shared for the production of both first and business class meals for different airline companies (see Figure 8)

**Figure 8 Equipments for hot kitchen**

Workers from the food production department collected the food materials from the store for processing. The hot kitchen had a booklet that listed all flight menus and the necessary ingredients to produce the menus so that every chef followed a standardised way to produce the food items. The reason behind was for any chef in the hot kitchen to have the capability to produce the menus with equal confidence and standard. The food production department produced all hot food that included hot meals, hot breakfast and hot snacks. Besides producing hot food, the hot kitchen also produced all other items in house. However, for Japan airlines, Flight Catering Company A had a specially allocated kitchen separated from the other kitchens, with 2 Japanese chefs in charge. (see Figure 9)

**Figure 9 Japan Airlines Kitchen**
The GM explained that the employment of the two Japanese chefs could cater to Asian airlines’ menus:

*We use the Japanese chefs to make every single sub-meal component, whereas a lot of places would buy that in. It means we can go for a lot of items that you just can’t buy. So we will be able to make many more Japanese components than you will be able to get in a Japanese restaurant. We make all the meals for Japanese airlines. We also do meals for Korean and we now offer sub-components to Cathy Pacific and Singapore. We use their skills to cross use individuality elements. Let me show you a typical completed trayset. I think this is a Korean economy meal trayset and this will be the second service. So, this will be a breakfast where it is going to be loaded onto the flight departing at 1830 from Amsterdam, and given to passengers before they arrive in Korea tomorrow morning at 6am. We have a picture of the menu specifications and the chefs will make an ideal tray setup and then everybody have to do the same.*

In the hot kitchen, the staff worked on 2 schedules so any food items produced were used immediately which meant that food items prepared in the morning were for the afternoon and night flights. When planning special meals, Flight Catering Company A took into account the various religious requirements - kosher, Hindu, Muslim. They also took into consideration personal requirements such as vegetarian, low salt, diabetic and low cholesterol. The list of special meals included: diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non-dairy, high fibre, bland and low protein meals. In the hot kitchen, there was a booklist that showed all ingredients allowed in a special meal and one chef would be assigned to be in charge for all the special meals. Special meals could be ordered through the passenger’s travel agent at the time of booking. The airlines would advise Flight Catering Company A at the time of ordering all meals for a particular flight. This normally happened 24 hours prior to flight departure.

Flight Catering Company A provided the same special oriental vegetarian meals to several other airlines that included Singapore airlines, Cathay pacific airways and United airlines (see Figure 10).
In the case of a last minute request for an additional diabetic meal, they would use other ingredients to replace them and avoid any cakes, chocolates, fatty fried foods, jams puddings or any syrups on it. Flight Catering Company A would also inform the airline companies if they could not provide the regular diabetic meal as their contract stated. Special meals were always clearly labelled with the passenger’s name to ensure the correct meal type was allocated correctly. For Kosher meals, it was usual to ask for 48 hours of preparation time to enable Flight Catering Company A to order and receive the meals from the nominated authorised supplier.

Flight Catering Company A not only had to produce a certain set of menus, but they had to change menus from time to time. Long haul flights (flights over 5 or 6 hours) might change menus monthly and carried less frequent travellers. For instance, Flight Catering Company A catered 4 menu rotations for for Continental Airlines, Japan Airlines and Pulkovo Airlines. An example was shown in Table 1 for United Airlines long haul flights with 3 menu rotations:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>July</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The internal process manager, Roman, also explained how they performed menu presentation,

*When an airline comes to us for a menu presentation, we present different varieties of stock items. We have in stock, let’s say...cheese, we present 4 or*
5 different cheese from which they can choose but, for example, the cheese they pick is the same as the Cathy Pacific cheese and orange juice is the same as UA. The reason we are doing that because we already know where we can buy that and for what price, so that makes it easy for us to make a quote to the airline company, a tender. So we use common food items or ingredients to provide to different airlines sometimes. Besides that, the time of menu presentation is very dependent upon our contract with the Airline Company. Such as we have a five year contract with Catchy Pacific and a 3 year contract with Surinam and Continental Airlines. So we only do the menu representation when the airline companies want us to provide them with new menus.

2.6 Food Assembly

2.6.1 Dish Packing

The next procedure was to assemble the prepared items into meals. The items were taken from fridges and assembled in accordance with the specification and photographs of menus. All items were labelled with a colour code label that clearly identified the day of production. Labels were also used to identify meal types, such as meat entree, fish entrée, poultry entrée. All these labels were purchased printed. The dish packing, tray setup and trolley assembly were all allocated in the production area, specifically in the centre of the kitchen unit for the convenience to receive any items for assembly from the different departments. The total number of dish packing was approximately 41,000 dishes in that week.

2.6.1.1 Economy Class Dish Packing

There were a number of methods for assembling meals – table-top, conveyor belt or cellular. In Flight Catering Company A, dish packing was done using table-top and conveyor belt. In consideration of the pros and cons of the different methods of dishing packing, the internal process manger, Roman, commented,

We talked about the belts and tables. You can see the belts, how good it is running for the assembly of Singapore airlines breakfasts now. A good belt cannot stop, a good belt runs from the first day to the last day. That’s a good belt so you can see for yourself if it’s a good belt or it
isn't. And good practices, 6 trays on the belt, not 5, not 7 but 6 trays on the belt. If you do 6 trays on the belt and if the belt keeps running, this is the most efficient way to produce meals. You make the most meals per person per hour. Instead of making 24 plates in one time, I started off making 6. I got out all the individual items: ingredients which are already prepared, that takes a little longer, 3/4 of an hour to prepare all the different items and then I started off by making 6, my starting temperature is 5 to 8 degrees. If I would to start and make all 24, my end temperature would be way above 10, so to keep it minimal and on the regulation side, I need to do 6 plates at a time. For sub-components, we are developing to do that built on tables instead of belts. Salads and pastries are done on belts still but we need to investigate if we need to change it over to table production.

The pictures below showed an worker collecting all the ingredients around her, and then laid out the 15 containers into the basket. Then, she put the omelette, broccoli, potato and mushroom into the containers and finally sealed the top cover. On the day of audit, there were 4 items of food materials in total and the worker took 5.15 minutes to assemble 16 main course meals (see Figure 11).

**Figure 11 Workers performing dish packing on a table station**

Another example of dish packing was shown in Figure 12, with 3 workers performing a dessert packing in three stages using a tabletop. In the first stage, one worker laid out 35 dessert plates onto a basket and poured KuroMitsu soya sauce onto each desert plate. Next, one worker put the Kurimi dofu onto the dessert plate. The final step was performed by the third worker who covered the container with a plastic lid and pasted
a sticker onto it. Altogether, the whole process took 560 seconds (9.33 minutes) to complete 35 courses of 3 items (see Figure 12).

**Figure 12 Desert packing**

For Surinam Airways, E/C salads were assembled using conveyor belts with 4 workers standing very close to each other. However, it was observed that 2/3 of the belt space were not in use. The first worker put the lettuce onto the plate, while the second worker put the Greek potato salads. At the same time, the third worker put the cucumber slices and tomato wedges onto the plate. Finally, the last worker put on the cover with a sticker and then placed them into the basket. They spent 2 minutes and 30 seconds for 16 salad plates with 4 items each. (see Figure 13).

**Figure 13 Four workers performing E/C salad assembly for Surinam Airways on a conveyor belt**

Figure 14 showed 3 workers assembling for Iran Air E/C salad employing a conveyor belt. One worker stood in front of the belt and put iceberg lettuces and cucumber slices onto a plate. The next worker was sitting on the right hand side of belt putting olives and tomatoes. The last person then put a film over the salad plate with a sticker on. In total, 16 salad dishes packed with 4 items each were completed in 3 minutes and 40
second; which included the time taken to cover it with film and attaching a red sticker to know that it was produced on that day.

**Figure 14 Three workers Performing E/C salad assembly for Iran Air on a conveyor belt**

In figure 15, two workers were assembling Continental Airlines E/C salad using a conveyor belt. One worker was standing at the front putting the lettuces and tomatoes, while the other worker stood at the end of the belt to cover the plates with a plastic lid with a red sticker on. They spent 1 minute and 25 seconds altogether to assemble 16 salads with 2 items.

**Figure 15 Two workers performing E/C salad assembly for Continental Airlines**

2.6.1.2 Business Class Dish Packing
Preparation of the business class meals required more skills, as we mentioned earlier in the hot kitchen section. The chefs would load each food item onto the main course plate and checked the quantities as well as presentation layout. During the audit, process co-ordinator, James, took 11 minutes to perform a layout for 6 Cathay Pacific Airways business fruit courses on a table-top. Prior to fruit course layout, James
retrieved all food items from the fridge and laid out 6 plates into the basket before assembling all the 6 items of 2 different types of lettuce, fig, artichoke hearts, orange/orange zest and sauce onto the plate. (see Figure 16).

**Figure 16 Performing layout and presentation for Cathay Pacific Airways business fruit course**

The picture below (Figure 17) showed a worker performing Japan Airlines business class western breakfast main course dish packing on a table-top in the business class assembly area. In total, 17 western breakfast main course packs with 6 items each, were completed in 15 minutes. The time recorded included putting in the butter milk pancake, tomato, grilled bacon, mushrooms, apple and maple compote, blueberries, plus filming it and attaching a blue sticker to identify its day of production.

**Figure 17 Workers performing layout and presentation for Japan Airlines business western breakfast main course**

Figure 18 showed the business class Korean style of main course which had the same items as economy class. The size of the china bowl was the difference between them. One worker assembling 7 items that included the Korean style of spinach, bean sprout, shiitake mushrooms, bell flower, black mushroom and beef bulgogi into a
China bowl, completed within 7 minutes and 15 seconds for 9 main courses. The items which came in bulk quantities were further divided into smaller portions and placed into the china bowls. Bread tins were often bulk loaded so that the cabin crew could warm them in the aircraft ovens prior to serving passengers.

**Figure 18 Workers performing Korean airways business main course on tabletop**

Table 2 below showed the average labour time spent on dish packing for each economy and business class meals.

**Table 2 The average labour time for dish packing E/C and B/C meals**

<table>
<thead>
<tr>
<th>Dishing</th>
<th>Assembly Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/C Breakfast</td>
<td>Table top</td>
<td>1</td>
<td>4</td>
<td>19.69 seconds</td>
</tr>
<tr>
<td>E/C Desert</td>
<td>Table top</td>
<td>3</td>
<td>3</td>
<td>5.3 seconds</td>
</tr>
<tr>
<td>E/C Salad Surinam Airways</td>
<td>Conveyor belt</td>
<td>4</td>
<td>4</td>
<td>2.1 seconds</td>
</tr>
<tr>
<td>E/C Salad Iran Air</td>
<td>Conveyor belt</td>
<td>3</td>
<td>4</td>
<td>4.5 seconds</td>
</tr>
<tr>
<td>E/C Salad Continental Airlines</td>
<td>Conveyor belt</td>
<td>2</td>
<td>2</td>
<td>2.65 seconds</td>
</tr>
<tr>
<td>B/C Fruit course Cathay Pacific Airways</td>
<td>Table top</td>
<td>1</td>
<td>6</td>
<td>110 seconds</td>
</tr>
<tr>
<td>B/C Western Breakfast Japan Airlines</td>
<td>Table top</td>
<td>1</td>
<td>6</td>
<td>52.94 seconds</td>
</tr>
<tr>
<td>B/C Dinner course Korean Airways</td>
<td>Table top</td>
<td>1</td>
<td>7</td>
<td>48 seconds</td>
</tr>
</tbody>
</table>
2.7 Tray Setup and Trolley Assembly
Conveyor belts and table-tops were employed in Flight Catering Company A to perform tray and trolley assemblies. For large-scale flight meals, the setup of a conveyor belt was more efficient because the running speed of a belt could affect an worker’s productivity. The worker had to match the speed of the belt as compared to working on a table-top, where the speed of an worker depended very much on how fast he/she desired.

2.7.1 Economy Class Meal Tray Setup and Assembly
Figure 19 showed five workers assembling economy class meals for United Airlines using a conveyor belt. Before they started to perform the tray setup, they retrieved 10 items from the storage. One worker was standing at the front to assemble a cup, water, and main course onto the trays. Two workers stood opposite each other across the belt. One assembled the main course and bread, while the other put salad, biscuit and cheese. A fourth worker assembled cutlery, dressing sauce and butter. Finally the last worker loaded the completed trays into the trolley cart. The whole process took 2 minutes and 15 seconds for 16 tray setups. Once all the meals were assembled for a certain flight, the completed trolley carts were immediately transported to the despatch area, which was just 45 seconds from the assembly area.

Figure 19 Five workers performing tray assembly for United Airlines on a conveyor belt

Figure 20 showed tray assembly for the Surinam Airways snack box. Four workers were allocated to assemble the meals on a conveyor belt. The first worker opened the box and put in the fruit yogurt. The second worker put in fresh fruit and cutlery. The third worker then closed the snack box and finally, the fourth person loaded the
completed snack box into the trolley cart. In total, they took 1 minute and 50 seconds to assemble 16 snack boxes of 3 items.

**Figure 20 Four workers assembling Surinam Airways snack box**

Figure 20 showed four workers assembling Japan Airlines economy breakfast on a conveyor belt. They took 2 minutes and 35 seconds for tray setups that consisted of 8 items (cup, cutlery, ketchup, main course, jam, bitter, fresh fruit and fruit yogurt). The time taken included loading the trays into the trolley cart. Japan Airlines had an electrically heated trolley cart which kept the food warm (see figure 21)

The GM, Gerry, explained how the electrically heated trolley cart worked and also the downside of it:

*We provide electricity to the cart and these trays have a heat plate on them. When you put the tray in here, there is an electronic connection made between the tray and the little pot on the side of the cart. Once electricity is turned on, that heats this plate and the tray heats up. That means we don’t have ovens but it does mean you are restricted to what meals you can supply because things like yoghurt and some soft foods will go mouldy. Is this only for JAL? No, there are a couple of airlines using that. It used to be very popular in North America but even they started to move away from it a little bit. Why? Because it does make other components on the tray heat up, for example, if you look at this, well that’s heating up. This is also heating up because you have got little plastic lids causing steaming. It may take 40 minutes to heat up and thus affect other components like soft desserts which melt and soft fruits will go mushy so it leads to restrictions on the menu you can offer.*
In figure 21, an worker fed the conveyer with all sorts of very interesting stuff. The rate at which he put the items on the belt determined the rate of actual production on this belt. Workers at the further end continued the assembly process while the last worker placed the completed items into the trolley.

In setting up the Pulkovo Airlines dinner box, four workers were allocated to assemble for one flight. Each box accommodated 16 disposal plastic trays, which took 2 minutes and 10 seconds for 7 items on each tray (cutlery, coffee cup, cheese, desert, salad, soft brown bread and butter) (see Figure 22).

This conveyor belt had four workers which took them 1 minute and 10 seconds for 16 tray setups of 4 items that consisted of cutlery, peach desert, creamy Dijon mustard and chocolate. They were standing on the same side of the conveyor belt; the first worker laid out the tray liner, while the second and third workers put the majority of items onto the tray, with the last person loading the completed trays into the trolley car (see Figure 23).
2.7.2 Business Class Meals, Crew Meal Tray Setups

In addition, figure 25 showed that the table top method was used for the business class tray set assembly. One worker set up 1 tray at a time in 1 minute and 15 seconds for 9 items that included tray clothes, cold plate, sesame oil, pickled cucumber, chopstick, side plate, butter flower, cutlery set and pepper paste with good presentation layout. On the day of audit, 600 business tray setups were assembled. Everyday, one worker was assigned to be in charge of special meals and crew meals. All Japan Airline’s meals were produced in Flight Catering Company A’s very own designated Japanese Kitchen.
A Japan Airline crew meal consisted of 9 items that included cup, fruit, butter, bread, jam, fruit plate and main course plate. They were then assembled into the box and loaded into the trolley cart. The worker took 55 minutes to assemble 20 crew meal boxes (see Figure 26).

Flight Catering Company A had two areas which only assembled special meals and crew meals. Since these meals were all specific requirements from the airline companies, each worker was in charge of each section. Any increased meal figures was passed from the operation department to each station’s superior to ensure that the additional meals for final passenger figures were loaded to the despatch area. Figure 27 showed that there was a request for an additional 2 business class meals on the Korean Air flight.
On the day of audit, the total number of tray setups were 5857 trays. The total number of different meals produced were: 600 business class meals, 20 first class meals and 135 special meals. In general, the average labour time for each economy class tray setup took 1.09 to 8.5 seconds and the average labour time for each business class tray setup took 75 to 150 seconds; depending on the number of different items that needed to be loaded onto the tray (see Table 3).

Table 3 Average labour time spent on tray setup and trolley assembly for E/C and B/C meals

<table>
<thead>
<tr>
<th>Tray Setup and Trolley assembly</th>
<th>Assemble Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each tray setup and trolley assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Airlines E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>10</td>
<td>8.4 seconds</td>
</tr>
<tr>
<td>Surinam E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>3</td>
<td>1.71 seconds</td>
</tr>
<tr>
<td>Japna Airlines E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>8</td>
<td>2.42 seconds</td>
</tr>
<tr>
<td>Pulkovo Airlines E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>8</td>
<td>2.03 seconds</td>
</tr>
<tr>
<td>Continental Airlines second meal E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>4</td>
<td>1.09 seconds</td>
</tr>
<tr>
<td>Continental Airlines dinner meal E/C</td>
<td>Conveyor belt</td>
<td>4</td>
<td>6</td>
<td>2.03 seconds</td>
</tr>
<tr>
<td>Korean Air B/C</td>
<td>Table top</td>
<td>1</td>
<td>9</td>
<td>75 seconds</td>
</tr>
<tr>
<td>Japan airlines crew meal</td>
<td>Table top</td>
<td>1</td>
<td>9</td>
<td>150 seconds</td>
</tr>
</tbody>
</table>

2.8 Despatch and Loading Areas
Food assembly workers sent the trolley carts to the despatch area once the workers had completed assembly. Each trolley cart took 1 minute to transport from the food
assembly area to the despatch area. Today's production schedule was for preparing tomorrow's flights, except for Japan airline. The entire catering requirement for each flight was checked based on the despatch final flight figure obtained from the operation department. Figure 28 showed an example of the final flight figure on a UA flight, that gave details on the quantity of milk, lemons, ice, ice canisters, bulk rolls, hot water, and bar carts (see Figure 28).

**Figure 28 Final UA passenger figure**

Before the trolley carts were loaded on board, they were checked for quantity and quality. In addition, the temperature of the food was checked by the despatch man and then sealed prior to sending them to the loading area. Each airline company had their own waiting zone in order to distinguish the different trolley carts from other airlines (see Figure 29).

**Figure 29 Quality Control form**

In general, the food was dispatched to the loading area 2 hours before flight departure. To ensure that Flight Catering Company A had enough time for loading, they had to compensate for transportation time to the aircraft. The despatch drivers checked the
quantities of trolleys on the final passenger figure before loading them onto the refrigerated vehicle, after which they were transported to the aircraft (see Figure 30).

**Figure 30 Despatch and loading area**

Flight Catering Company A had a transport fleet of ten trucks, one large van and 4 small vans. Quality of the assembled trays was checked by 4 employees in the despatch area. The work schedule was divided into 4 shifts which were from 05:00 to 14:00, 06:00 to 15:00, 10:00 to 19:00 and 12:00 to 21:00pm. After the September 11 incident, flights from United Airlines and Continental Airline’s were required to have a security check by two despatch men. Each vehicle was specially designed so that the vehicle body could raise to the height of the aircraft doors (see Figure 31). 25 lorry drivers were on a 6 week rotation and their work shifts were arranged according to flight schedules. The 6 shifts were from 05:00 to 14:00, 06:00 to 15:00, 07:00 to 16:00, 08:00 to 17:00, 10:00 to 19:00 and 12:00 to 21:00. In order to reduce the loading time, four employees that included one supervisor, were allocated for each Japan Airline flight. Bad planning in vehicle allocation could result in thousands of pounds of overspending, or problems in getting the meals onto the plane in time. All the completed trolleys had to be loaded onto the aircraft 1 hour before flight departure. The used trolley carts collected from the aircraft needed to be uploaded into the vehicle before the newly assembled trolleys were loaded onto the aircraft.
Figure 31 Outside of a Transport Vehicle

2.9 Equipment area

The equipment store had nearly 3000 different items in total. A list of part level code of each airline company was used to assist workers to manage the high volume and high variety of equipment items (see Figure 32).

Figure 32 List of Korean Air part level code

Each part item in the list was indicated with figures of maximum quantity and minimum quantity next to it. For instance, there should be at least 95 full size, trolley carts for Surinam Airways in the store and if the number was less than 95, the storeman informed the warehouse to top up the shortage in quantity (see Figure 33).
Each airline would supply their equipment. Alpha It was the responsibility of Flight Catering Company A to store, clean and manage these equipment. Majority of airline companies had a stock count conducted every month. If there happened to be shortage in equipment, Flight Catering Company A would get the necessary equipment from the warehouse and divided everything according to schedule. The equipment department supplied all the cutlery, china bowl, napki, pepper and salt (see Figure 34).

**Figure 34 Equipment area**

2.10 Washing Area

A number of different techniques to remove waste from trays carried to the waste-holding area included bins, belt conveyors, screw conveyors, river or vacuum systems (Jones, 2003). Flight Catering Company A had 2 elevators to assist workers to off load the complete flight equipment into the wash up area. To ensure good flow on the belt, the trolleys were sorted according to flight class ie. First, Business or Economy. Glass and carton were disposed of separately. One worker stood at the end of the washing conveyor belt to sort out the different equipment items and then put them into a basket. There were 5 common track washing machines in the washing area and were
Flight Catering Company A Descriptive Case Study of Operational Processes
categorised according to the different types of equipment they handled. The internal process manager, Roman, described the five machines:

*Machine number 1 is the trolley machine, we can do the ovens, the big crates. Number 2 is the glass machine with a special system built in so the glass comes out properly clean and dry. Number 3 is a small dish washer. Number 4 is the big dish washing machine and number 5 is the cutlery and tray set machine. For the disposable trays, one worker puts the tray on the belt. At this moment, we are not going to put one guy at machine number 2, because there is no glass on. If there is glass on, one guy needs to be there, to take glass that comes through the machine. So, this guy is free, he can do other things. This goes over the belt, we are only working with machine number 4, so these people do disposable. This one put it into the machine and then the last guy is stationed there, clean it comes through that machine and it picks out automatically and then the last guy takes the tray so these the butter, everything goes to the big crasher.*

Flight Catering Company A had to deal with large amounts of waste offloaded from aircrafts, especially for the long haul flights. The internal process manager, Roman, said that the unit practised recycling of items whenever possible:

*We are looking at the inbound flights of Continental, a lot of articles that comes from the inbound flights to Amsterdam, it comes into the wash up area and we put it separately to re-pack again and to re-use again. The more we can save, the less they have to buy. The airline company do not care, so normally we don't just throw them away. For example, Continental Airlines' flight, we fill up 60 cans of mineral water per flight more or less, it depends. We know, let's say, for this, why throw this away, I mean it's a waste of money. You need to look if it's not dirty, you can wash. Only Continental Airline allows us to recycle.*

To avoid messing up all the equipment, Flight Catering Company A performed the wash up for the same airline company at the same time in one go. For heavily stained
cups or plates, they would soak them into white plastic bins with cleaning agents and re-washed them again. Once all the equipment had been washed, the worker then sent them back to the equipment store. Once in the equipment store, the worker would count them. In the wash up area, the number of items to be washed was based on the number of trolley carts that accommodated all items. Any waste food from the trays were put into one compactor. 20% of the equipment were non-disposal items like plastic cutlery, while 80% of the equipment to be washed were non-disposal items for instance, glassware items. Items for disposal were all thrown into the orange bins (see Figure 35).

Figure 35 An example of disposal items

During peak times, equipment from trolleys unloaded from aircrafts occupied a lot of space in the washing area. All the equipment to be washed relied heavily on five machines. There was an enormous gap in terms of the amount of equipment to be washed during peak and off peak times. Currently, there were 7 to 8 workers in the wash area. Daily work started at 06:00 and finished at 17:00. On a busy day or during peak periods, all the five machines had to run continuously to complete the wash up of all the equipment.

On a daily basis, Flight Catering Company A had most of their people washing rather than working on the food. They approximately washed between 600,000 and 800,000 pieces of equipment, which then had to be processed and packed ready for tomorrow’s or the day after tomorrow’s flight. So, more staff were involved in looking after the equipment and cans of juices than in making food during peak periods. The freshly completed washed materials were properly arranged and
delivered to the relevant departments. The washing of napkins and towels were outsourced (see Figure 36).

Figure 36 Washing Area

![Washing Area Images]

2.11 Bonded Warehouse

For bar cart packing, workers assembled the bar cart according to the packing plan as specified by airline companies. The beer, wine and sakei for Japan Airline were required to be chilled the night before departure. At the end of a completed flight, the various items in a bar cart could become jumbled. If the items in the bar cart were sorted prior to reloading the carts, then time saving could be achieved in the region of 50 to 60 hours a week as internal process manager Roman (see Figure 37).

Figure 37 Bar cart assembling area

![Bar cart assembling area Images]
A Case Study on Flight Catering Company B

By Yevvon Yi-Chi Chang
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1. Company Background

The conglomerate group, where Flight Catering Company B is under one of its smaller division served over 100 airlines at 62 airports in 8 countries that spanned across 4 continents: UK, Continental Europe, USA, Middle East and Australia. The company comprised of three divisions: The airport catering division consisted of 28 restaurants and bars at 7 airports in the UK. The retail service division had an extensive range of shopping outlets at 20 UK airports and 80 shops in 4 overseas location, that included Duty and Tax-free shops. Lastly, the flight catering group, which Flight Catering Company A is directly under, operated 32 flight kitchens at 27 airports in the UK, as well as kitchens in Amsterdam and Orlando, USA.

In Birmingham (UK), Flight Catering Company B had a catering service unit situated just about 1 mile away from the Birmingham International Airport. The day to day function of Flight Catering Company B was to provide catering services to a mixture of long haul and short haul airlines arriving and departing at Birmingham International Airport. At the moment, the unit served a total of 23 airlines, of which two were long haul airlines (Emirates and Continental airlines) and the rest comprised of both charter and short haul airlines. Flight Catering Company B occupied two floor spaces of 3335 m² (see Figure 1). The unit had a capacity in excess of producing 80,000 meals per week for the increased number of holiday makers during peak seasons.
Figure 1 Layout of Flight Catering Company B
2. Descriptive Case Study of Operational Processes

2.1 Two Key Performance Indicators of Management
In order to perform well, Flight Catering Company B had to achieve certain key performance indicators (KPIs). The three main KPIs were namely; meals per hour, cost per hour and meals per flight. Their process control manager, Tim, further commented:

*A food related department work towards meals per hour KPI, while the workers who load meals onto the flights work towards hours per flight KPI. For instance, workers in the hot kitchen have to achieve 130 meals per hour of labour used. In cases where this KPI value is not achieved, the management would like to know why they are below that value. In addition, there are a number of other KPIs such as cost per hour and meals per flight. Therefore, on a day to day basis, they use KPIs to manage the business. Every meal in Flight Catering Company B is timed and then input into our computer system which tells us the targeted number of meals to produce in a certain time. By looking at historical data, the computer system not only assists our company to set KPI targets within budget but also assess performances of our managers. Any manager’s primary responsibility is to ensure that a good-quality product is produced before loading into the aircraft in a clean environment within company’s guidelines.*

2.2 Functional Flexibility and Temporal Flexibility
Flight Catering Company B employed a total of 186 staff. Working hours varied for each department based on schedules generated by the operation department. For instance, economy class food assembly was divided into 2 shifts. One shift started from 6:00 am to 4 pm, while the other shift started from 8:30 am to 7 pm. The average working hours was 10 hours per day which included a 30 minutes lunch break. On the other hand, there were 2 shifts for the hot kitchen: one from 3 am to 3pm, while the other shift started from 4:30am to 3 pm; in order to produce high quality of food by ensuring freshness and not pre-cooked and stored for a few days. Hence, all business class meals were cooked in half a day in advance prior to flight departure.
Functional flexibility was clearly exhibited in Flight Catering Company B. During seasonal peaks from May to July, the company recruited some temporary employees to supplement a smaller core of full time employees, thereby increased the productivity to meet the rise in demand.

To ensure all staff gave their best towards achieving the company’s long and short-term objectives, Flight Catering Company B provided four weeks of training course which consisted of induction course on the company, hygiene course, fire safety, and all the compliance trainings. Once the employee was assigned to work in a particular department, he/she would be given on the job training. Furthermore, the company provided specific training courses occasionally, for instance; the hot kitchen department would provide training courses for chefs whenever airline companies changed their menus.

In Flight Catering Company B unit, the workers were shuffled daily to work on different flight schedules. However, not all workers could be shuffled to take on the different tasks. For instance, chefs required a special technical skill, so they would not take any economy class worker and put them into the hot kitchen. The food assembly team manager, Robert, explained the reason for shuffling workers on different flight schedules:

*The primary reason for shuffling flight schedule is to promote cross training of workers which then increases the operations flexibility. The swap of workers is normally within the same process. For instance, to cover shortage of workforce sometimes they will take tray assembly worker and maybe put them into cold assembly or despatch department.*

2.3 Information Technology Implementation of Material Requirement Planning

The communication medium between flight caterers and airline companies becomes a significant tool to fight time and money with other competitors in this business. In Flight Catering Company B, they implemented a computer system to assist them in building airline schedules, in order to forecast the quantities of meals required. This computer system is known as the Flight Catering Management System (FCMS) in the flight catering industry. Orders were planned in advance, via materials requirement
planning using the FCMS to eliminate unnecessary waste. The forecast of the quantities required for certain ingredients, was first achieved by stating the menu specification agreed with the airline company; which then allowed the requirement for raw materials and ingredients to be estimated. Within the menu specification, there were details containing meal description, menu rotation, product code, entrée and recipe. The standard recipe was an essential component in flight food production. For instance, Uzbekistan Airway economy meals of entrée: 80 gm of lamb masala, 55 gm of boiled rice and one coriander nanna. Hence, if a flight had 200 economy class passengers, Flight Catering Company B was required to place 16,000 gm (200 x 80) of lamb masala and 11,000 gm (55 x 200) of rice from suppliers. The combination of the knowledge of flight schedule and recipe details was the advanced information for input into Flight Catering Company B’s FCMS to forecast and reduce inventory stock (see Figure 2).

Figure 2 Menu specification

The implementation of MRP to eliminate waste, indicated that Flight Catering Company B used a Pull-system instead of a Push-system. Traditional manufacturing plants uses a push system where production schedules are developed for maximum capacity based on sales forecast pushing materials downstream. With FCMS, the process control manager could edit the amount of component parts. He could increase or decrease, for example; if the computer read 10 kg for a particular component but in actual fact there was only 8 kg left, he could edit it to reflect the current amount. This was how the purchasing forecast was planned which helped them to minimise any waste. Therefore, the internal flight catering management system was an essential tool that not only aided in planning forecasts but also in placing orders with suppliers based on the forecasted data.
After obtaining the forecasted data, the process control department passed the information to the operation department. The operation department was the day to day contact which dealt with operation changes, live operations, off schedule flights, flight diversions and also accept passenger figures on a daily basis (see Figure 3).

**Figure 3 Work flow of Flight Catering Company B**

Hence, they knew how many meals to produce for each flight. They generated figures pertaining to information that included the number of meals to be produced (crew, passenger and special meals) and flight schedules (estimated arrival and departure time). This piece of information was called the ‘MayFly’ schedule (see Figure 4). Inside ‘MayFly’, all the information were for the following day schedules. Every
morning, each team manager of different departments would collect a copy of the ‘MayFly’ for preparing the next day schedules. Hence, the workers were actually preparing for tomorrow’s flights based on today’s ‘MayFly’.

Figure 4 A typical ‘MayFly’ schedule

2.4 Goods Inward

In Flight Catering Company B, there were 52 suppliers who supplied ingredients and materials. Delivery of goods was continuous from morning till afternoon. Goods received documents were passed to the stores team who would then check all items arriving at the unit. The food supplier manager, Dean further remarked:

*We have a report generated by FCMS that tells us basically what the opening stock of each individual product was, how many we received in one month, what the closing stock was and what we actually used. The actuaries are what we actually sold and we go thorough this is to see where we lost money, gain money etc. We use that report to obviously stop us losing money and then go forward.*

Approximately, there are 200 different dry items, 700 different frozen items and 600 different chilled items. In total, there are about 4000 items in the store. To reduce cost, 10% of the items are outsourced. For instance, sandwiches for British Airways are outsourced from suppliers. Flight Catering Company B explained the rationale behind this is because the cost of producing large volume of sandwiches in their unit is more costly than
outsourcing them from suppliers. However, if the quantity of sandwiches requested by an airline (for instance, Lufthansa Airline) is small, they will produce them in-house.

Besides the obvious check of product type and quantity, they would also check for quality and for chilled items. In addition, they checked the temperatures of the food items too. Any items that failed to reach the agreed standards or were not within the correct temperature guidelines were rejected and returned to the supplier. The storeman then separated the goods accordingly to dry items, wet items and frozen items. Dry items were food items such as pepper, salt, soya sauce and chips (see Figure 5) that could be stored for very long periods of time; and not required to be frozen to keep fresh. Items like juices, milk, fresh vegetables and salads were chilled; while items with a relatively shorter lifespan like meat had to be frozen to keep them fresh. On the day of audit, 103 different dry items were received into the dry store and 107 different chilled items were stored in the fridge.

Figure 5 Items in store

In addition to different classifications of food items, items for the same flight schedule were labelled for easy identification when collected by other departments for processing. The head chef, Terry, and food assembly team manager, Robert both commented on the procedure they used to identify items:

The fresh sandwiches outsourced from other manufacturers were attached with colour stickers in order to distinguish which day they were produced and for easy identification by our staff so that they know which items should be used based on the first in first out concept. Different colour stickers represent different days of the week for instance, blue is Friday.
yellow is Saturday, Sunday is pink, white is Monday, Tuesday is red, Wednesday is brown and Thursday is green. There are no items in the store that are kept for less than a day. For instance, sandwiches are usually kept in the store for 3 days (see Figure 6).

Figure 6 Sandwiches, ham and cheese kept in store

2.5 Food Production

The main workforce in the hot kitchen consisted of 9 chefs and 1 junior chef. In the hot kitchen, there were 11 large scale hardware equipment which included: deep fat fryers x 3, chargrill x1, salamander x 2, brat pans x3, convection ovens x 4, steamer x 1, mixer x 1, stove (gas) x 2, chopping machine x1, blenders x2, robot loupe x1. These equipment were all shared for the production of both first and business class meals for different airline companies (see Figure 7).

Figure 7 Equipment for the production of first and business class meals

Workers from the food production department collected the food materials from the store for processing. The hot kitchen had a booklet that listed all flight menus and the necessary ingredients to produce the menus so that every chef followed a standardised way to produce the food items. The reason behind was for any chef in hot kitchen to have the capability to produce the menus with equal confidence and standard. The food
production department produced all hot food that included hot meals, hot breakfast and hot snacks. Besides producing hot food, the hot kitchen also produced all items cooked in house except kosher meals.

The hot kitchen only produced all first and business class meals in house while economy class meals were all outsourced from 3 food manufacturers, namely; Stanley Green, Sarah Brownridge and Pourshins. Stanley Green supplied all bulk economy class hot meals to all Alpha catering units throughout UK. For business class meals, the hot kitchen in Flight Catering Company B produced virtually everything in-house. For instance, all the dressings, sauces and salads were produced by themselves. A team of 3 chefs was designated to prepare the meals for each flight. One chef would prepare all the ingredients and materials needed for the flight while the other chef would cook the ingredients and materials. Once all the meat items such as chicken, lamb and fish were cooked, they would be placed in a blaster to chill and then transferred to a holding fridge. The third chef would then perform the layout and presentation of the meals (see Figure 8).

Figure 8 Chef performing layout for business class meals

The head chef, Terry, emphasised the need for freshness and how they coped with last minute requests:

We will do everything as fresh as possible. Particularly for Emirates airline, 3 of our chefs will work on a rotational basis for seven days. A chef will come in at 3 am in the morning to prepare cold food items for Emirates flight in the morning. In hot kitchen, they work on 2 schedules so any food items produced, are used immediately which means food items prepared in the morning are for the afternoon and night flights. Vice versa, food items prepared in the afternoon and night are for the
morning flights. However, food items can be produced one day in advance for charter flights. If there are any meals that are over produced and cannot be adapted for the usage of other airlines, they are sent to the company’s canteen for their staff to consume instead of throwing them away.

When planning special meals, we take into considerations such as religious requirements - kosher, Hindu, Muslim as well as personal requirements - vegetarian, low salt, diabetic and low cholesterol. The list of special meals include: diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non dairy, high fibre, bland and low protein meals. In the hot kitchen, there is a booklist that shows all ingredients allowed in a special meal. Our staff will strictly follow the booklist guidelines which make the preparation of special meals easy to follow. Special meals may be ordered through the passenger’s travel agent at the time of booking. The airlines will advise the caterers at the time of ordering all meals for a particular flight. This normally happens 24 hours prior to the flight departure.

In the case of last minute request, for instance, if there is a request for one additional diabetic meal, we will use other ingredients to replace them and avoid any cakes, chocolates, fatty fried foods, jams puddings or any syrups on it. Of course, we have to inform the airline companies if we cannot provide the regular diabetic meal as our contract stated. In addition, we make sure we have enough products to cover passengers’ special requests. For instance, plain chicken apart from using it in regular hot meals can also be used for low fat, diabetes, low cholesterol as well as children meals. These types of special meals are produced using the airlines normal menu as a guideline and adapting the products to suit the specific requirement. Special meals are always clearly labelled with passenger’s name to ensure the correct meal type is passed to the right person. For Kosher meals, it is usual to ask for 48 hours of preparation time requirement to enable us to order and receive the meals from the nominated authorised supplier.
Flight Catering Company B not only just produced a certain set of menus, they had to change menus from time to time. For the scheduled flights, meals were provided for a set period in time. Every airline rotated their menus for various times of the year, with most airlines changing their menus every six months - six months for summer and six months for winter.

Long haul flights (flights over 5 or 6 hours) might change monthly because they carried less frequent travellers. The table below showed an example of how menu was rotated, where Flight Catering Company B catered for Emirates Airlines and Continental Airlines long haul flights with 4 menu rotations:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cycle</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Short haul flights (flights less than 5 hours) might decide to change frequently, for example every week. This was normally in consideration of the many business travellers who commuted on a regular basis and would soon tire of a menu which seldom varied. British Airways in particular had up to 3 rotations of menu which changed every week.

2.6 Food Assembly
2.6.1 Dish Packing

The next procedure was to assemble the prepared items into meals. The items were taken from fridges and assembled in accordance with the specification and photographs of menus. All items were labelled with a colour code label that clearly identified the day of production. Labels were also used to identify meal types, such as meat entree, fish entree and poultry entree. All these labels were purchased per printed. The dish packing, tray setup and trolley assembly were allocated in the production area, specifically in the center of the kitchen unit for the convenience to receive any items for assembly from different departments. The total number of dish packing was approximately 4100 dishes in that week.
2.6.1.1 Economy Class Dish Packing

There were a number of methods of assembling meals – table-top, conveyor belt or cellular. In Flight Catering Company B, dish packing was done using the table station with various numbers of staff working at the table. For instance, 4 workers were allocated to assemble breakfast main course where two workers stood on one side, while the other two on the opposite side of the table station. The pictures below showed two workers put the sausages, tomatoes, scramble eggs, chicken nuggets into foil containers, and then passed the containers over to the other side for workers to seal the top cover and put into the blue basket. On the day of audit, there were five items of food materials in total and 4 workers took 4 minutes and 50 seconds to assemble 16 main course meals (see Figure 9).

Figure 9 Workers performing dish packing on a table station

The different meals of dish packing involved different workers. The pictures below showed 2 workers performing a cold dish packing in two stages using a table-top. In the first stage, one worker spent 10 minutes to assemble 90 cold courses which included, salads, pastas, and orange slices onto the trays. Next, the worker put the ham onto the cold salad trays and then randomly conducted a quality check which altogether took 10 minutes to complete 100 courses. The time taken did not include putting the chicken onto the trays and sealed with plastic lid as final meal presentation (see Figure 10).
2.6.1.2 Business Class Dish Packing

The business class meals required more skills, as we mentioned earlier in the hot kitchen section. The chefs would load each food items onto the main course plate and check the quantities as well as presentation layout. Thus, one chef took 12 minutes for performing layout for 16 Emirates business main courses on a table-top. All the business main courses were assembled in an area next to the hot kitchen. Prior to main course layout, the chef retrieved all food items from the fridge and the items were loaded on the bulk trolley cart next to his table station. Items which were supplied in quantities such as first class cheese trays, hors d’oeuvre trays, etc were loaded directly into trolleys carts. These types of products were “bulk loaded” because they were not preset into individual portion on trays. Bread items were often bulk loaded too, so that the cabin crew could warm them in the aircraft ovens prior to serving them to the passenger (see Figure 11).

Figure 11 Chef performing layout and presentation

The picture below (Figure 12) showed an worker performing butter dish packing in the business class assemble area employing the table-top. In total, 32 butter dish packing were completed in 13 minutes which included filming it and attaching blue colour sticker to identify it was produced on that day.
Table 2 below showed the average labour time spent on dish packing for each economy and business class meals.

<table>
<thead>
<tr>
<th>Dishing</th>
<th>Assemble Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/C Breakfast</td>
<td>workstation</td>
<td>4</td>
<td>5</td>
<td>4.5 seconds</td>
</tr>
<tr>
<td>E/C Cold Dish</td>
<td>table top</td>
<td>2</td>
<td>5</td>
<td>6.3 seconds</td>
</tr>
<tr>
<td>B/C Main Course</td>
<td>table top</td>
<td>1</td>
<td>5</td>
<td>45 seconds</td>
</tr>
<tr>
<td>B/C Butter</td>
<td>table top</td>
<td>1</td>
<td>3</td>
<td>24.37 seconds</td>
</tr>
</tbody>
</table>

2.7 Tray Setup and Trolley Assembly

Work stations were employed in Flight Catering Company B unit to perform tray and trolley assemblies. Two and a half years ago, they used to have line layout with 3 or 5 workers working on the belt. They found that the significant difference between work station and conveyor belt was the fact that the work station was more efficient and could easily trace back whose responsibility it was in the event of any mistakes. For large scale flight meals, the setup of a table-top occupied more space.

2.7.1 Economy Class Meal Tray Setup and Assembly

Figure 13 showed two workers assembling for Turkmenistan economy class meals using a work station. Before they started to perform the tray setup, they retrieved 13 items from the storage that included bread, water, chocolate, 2 dressing sauces, desert, cutlery, cream milk, butter, cup and assembled them onto the disposal plastic tray. One worker assembled 7 items on two trays simultaneously. Afterwards, he passed the semi-packed tray to another worker who put the bread and biscuit onto the tray and
finally closed the cover and put into the box. Each box accommodated 16 disposal plastic trays which took 6 minutes to finish which were then sealed and loaded into the bulk trolley cart. Once they assembled the total number of meals for a certain flight, they moved the trolley into the despatch area which was just 30 seconds from where they were situated.

**Figure 13 Two workers performing tray assembly for Turkmenistan E/C meal on a work station**

Figure 14 showed tray assembly for Uzbestan economy class meals. Only one worker was allocated to assembly the meals on her own work station. She took 4 minutes and 50 seconds to assemble 7 items which included butter, cutlery, salad, cheese, cup bisque, and dessert into the trolley cart. Each tray was setup one at a time.

**Figure 14 A worker assembling Uzbestan economy class meals**

Figure 15 showed another example of an worker assembling continental economy breakfast, where each tray was setup one at a time. She took 4 minutes to assemble 16 trays that consisted of 5 items (cutlery, scorn, jam, clotted cream and cream Dijon mustard) which included the time taken to load them into the trolley cart.
Sometimes, two workers were allocated to assemble for one flight. For instance, in setting up Continental airlines breakfast, two workers took 2 minutes for assembling 16 tray setups of 5 items (cutlery, scorn, jam, clotted cream and cream Dijon mustard) which included the time taken to load the trays into the trolley cart (see Figure 16).

For Britannia economy class flight, one worker assembled 10 items of cheese, chocolates, butter, cream, bisque, bread, water, cutlery, main course plate, cup, cream milk onto two trays at the same time. She took 5 minutes for 16 trays setup which included the time taken to put them into the bulk racket.
The picture below (Figure 18) showed one worker assembling one tray at a time which took him 8 minutes to put together 6 items (bread, dressing, butter, cutlery, salad, desert) for 16 trays. The time recorded included the time taken to load them into the trolley cart. Later on, another worker joined him and altogether, they spent 4 minutes each for 16 tray setups.

**Figure 18 A worker assembling Airtour meals**

![A worker assembling Airtour meals](image)

This work station had two workers which took them 3 minutes and 20 seconds for 16 tray setups of 9 items, that consisted of bread, butter, milk, jam, cup, fruit, cutlery, main course plate orange juice. One was standing, putting majority of items onto the tray; while the other was sitting next to the trolley cart and then put the orange juice and fruit into the trolley (see Figure 19).

**Figure 19 Two workers assembling Mytravel economy class meals on the work station**

![Two workers assembling Mytravel economy class meals on the work station](image)

Same as above, two workers assembling for Scandinavian flights on the work station were shown in Figure 20. The two workers took 8 minutes for 16 tray setups with 8 items (china cup, cold dish, desert, bread, cutlery, milk, butter, salad) and the time taken included loading them into the trolley cart.
2.7.2 Business Class Meals, Crew Meal Tray Setups

In addition, the table top method was used for long haul Emirates business class tray set assembly. One worker set up 16 trays one at a time within 12 minutes for 7 items that included tray clothes, napkin, pepper, slat, china plate, cutlery, butter and jam with good layout presentation. There were 8 different types of business tray setups and on the day of my visit, they assembled 114 trays in total. Business class assembling workers also had to setup trays for special meals and crew meals. Altogether, there were 13 different types of crew meals and 296 tray setups were assembled in a day by 2 workers.

For the short haul British Airways business class meal, one worker adopted the work station method to assemble tray setups in the production area. 10 items that consisted of napkin, cup, glass, fruit, butter, bread, dressing, milk, orange juice and main course plate were assembled onto the tray and loaded into the trolley cart. The worker assembled both trays simultaneously and took 7 minutes (see Figure 22).
Flight Catering Company B had two section areas which only assembled special meals and crew meals. Since these meals were all specific requirements from the airline companies, each worker was in charge of each section. From the above figure, the total number of tray setups were 6986 trays, and the total number of meals for charter flights were 2000. Of the 6986 tray setups, 12.3% were special meals. In general, the average labour time for each economy class tray setup took 3 to 30 seconds and the average labour time for each business class tray setup took 26 to 45 seconds, depending on the number of different items that were required to be loaded onto the tray (see Table 3).

Table 3 Average labour time spent on tray setup and trolley assembly for E/C and B/C meals

<table>
<thead>
<tr>
<th>Tray Setup and Trolley assembly</th>
<th>Assemble Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each tray setup and trolley assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkmenistan E/C</td>
<td>workstation</td>
<td>2</td>
<td>16</td>
<td>11.25 seconds</td>
</tr>
<tr>
<td>Uzbenstan E/C</td>
<td>workstation</td>
<td>1</td>
<td>7</td>
<td>16.8 seconds</td>
</tr>
<tr>
<td>Continental E/C</td>
<td>workstation</td>
<td>1</td>
<td>5</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Continental E/C</td>
<td>workstation</td>
<td>2</td>
<td>5</td>
<td>3.75 seconds</td>
</tr>
<tr>
<td>Britannia E/C</td>
<td>workstation</td>
<td>1</td>
<td>6</td>
<td>18.75 seconds</td>
</tr>
<tr>
<td>Airtour E/C</td>
<td>workstation</td>
<td>1</td>
<td>6</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Mytravle E/C</td>
<td>workstation</td>
<td>2</td>
<td>9</td>
<td>6.25 seconds</td>
</tr>
<tr>
<td>Scandinavian E/C</td>
<td>workstation</td>
<td>2</td>
<td>8</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Emirates B/C</td>
<td>table top</td>
<td>1</td>
<td>7</td>
<td>45 seconds</td>
</tr>
<tr>
<td>British B/C</td>
<td>table top</td>
<td>1</td>
<td>10</td>
<td>26.25 seconds</td>
</tr>
</tbody>
</table>
2.8 Despatch and Loading Areas

Food assembly workers sent the trolley carts to despatch area once they had completed assembly. The time taken for each trolley cart to be transported from the food assembly area to despatch area was 1 minute. Today’s production schedule was for preparing tomorrow’s flights. Thus, the trolley cart’s door was opened to keep it cool (see Figure 23). Before the trolley carts were loaded on board, they were checked for quantity and quality by the despatch man and then sealed prior to sending it to the loading area.

**Figure 23 Despatch fridge**

The food was dispatched to the loading area 2 hours before flight departure. Quality check on food was conducted by an authorised dispatcher before being loaded onto the refrigerated vehicle and then transported to the aircraft (see Figure 24).

**Figure 24 Loading area**

Flight Catering Company B had a transport fleet of eight, $7\frac{1}{2}$ tonne vehicles and sixteen, 17 tonne vehicles. They had 42 drivers and 5 dispatch quality check workers. The work schedule was divided into 4 shifts which were from 11:00am to 7:30pm, 5:00 am to 1:30pm, 5:00am to 2:00pm and 9:00 am to 7:30 pm respectively. Drivers of
the 17 tonne vehicle were allowed to drive the 7 ½ tonne vehicle in cases of any shortage in workforce. Each vehicle was specially designed so that the body could raise to the height of the aircraft doors (see Figure 25). To cater for an A747 Jumbo aircraft, three vehicles were required; while a 737 aircraft only required one. Bad planning in vehicle allocation could result in thousands of pounds of overspending, or problems in getting the meals to the plane on time.

Figure 25 Inside of a transport vehicle

Duty free goods to be loaded on board were collected from the bonded store by drivers. All the completed trolleys had to be loaded onto the aircraft 1 hour before flight departure. The used trolley carts collected from the aircraft were uploaded into the vehicle before the newly assembled trolleys were loaded onto the aircraft. The entire catering requirement for each flight was checked based on the despatch check list (see Figure 26) from the operation department. The check list detailed the quantity of milk, lemons, ice, ice canisters, bulk rolls, hot water, and bar carts.

Figure 26 Despatch check list
2.9 Equipment Area

For the airlines equipment, 2 workers were assigned to 3 specific airlines and rotated on shifts for different airlines each day. The equipment store had nearly 1000-2500 different items in total. A list of “part level” code of each airline company was used to assist workers to manage the high volume and high variety of equipment items (see Figure 27). Each part item in the list was indicated with figures of maximum quantity and minimum quantity next to it. For instance, there should be at least 6 cheese boards for Emirates Airlines on the shelf and if the number was less than 6, the storeman had to inform the warehouse to top up the shortage in quantity.

![Figure 27 List of Emirates Airlines part level code](image)

Each airline would supply their equipment. It was the responsibility of Flight Catering Company B to store, clean and manage these equipment. A stock count was conducted every month and if there was shortage in equipment, they would get the necessary equipment from warehouse and divided everything according to schedule. Alternatively, they emailed to airline companies to request for the shortage. The equipment department supplied all the cutlery, salt and pepper and sealed them into the trolley cart and put into fridge (see Figure 28).

![Figure 28 Equipment area](image)
2.10 Washing Area

A number of different techniques to remove waste from trays carried to the waste holding area include bins, belt conveyors, screw conveyors, river or vacuum systems (Jones, 2003). In Flight Catering Company B, two workers unloaded trays from trolleys and transferred them by hand onto the conveyor belts associated with the ware washing system which had special wash tunnels for trolleys as well as for crockery, trays and other special baskets before being taken to storage locations on trolleys. One worker stood at the end of washing conveyor belt to sort out the different equipment items and then put into a basket. The temperatures for pre-wash, wash and rinse were required to be recorded and checked three times daily (Figure 29). The pre-wash temperature had to greater than 40 degrees.

![Figure 29 Temperature inspection list](image)

There were three common track machines which were categorised according to two different types of equipment. The first type of equipment which included all kinds of rotables like cutlery, cups, trays and crockery were washed by one of the track machine. The second track machine was for washing baskets and trolley carts only. The shift leader, Gohar, in the wash up area explained the washing process as followed:

*To avoid messing up all the equipment, we do the wash up for the same airline company at the same time in one go. For heavily stained cups or plates, we will soak them into white plastic bins with cleaning agents and re-wash them again. Once all the equipment have been washed, the storeman collects them and send them back to the equipment store. The*
storeman then counts them. In the wash up area, we don’t count by the number of items to be washed but instead, we count by the number of trolley carts that transport all the items like rotables to the wash up area. Any waste food from the trays are put into one compactor and 8 blue bins. 70% of the equipment are disposal items like plastic cups, plastic cutleries (see Figure 30), while 30% are non-disposal items for instance, glassware items. The disposal equipment are all thrown into the blue bins.

Figure 30 An example of disposal items

During peak times, equipment from trolleys unloaded from aircrafts occupied a lot of space in the washing area. All the equipment to be washed relied heavily on three machines. So, there was a very huge gap in terms of the amount of equipment to be washed during peak and off peak times. Currently, there were 7 to 8 workers in the wash area. There were 2 work shifts a day where one started from 6:30 am to 3:00 pm and the other from 10:00 am to 6:30 pm. On a busy day or during peak times, all the three machines had to run continuously to complete wash up of all the equipment. Hence, Flight Catering Company B scheduled a continuum of 2 work shifts (morning shift and night shift) if necessary.

The washing of 28 Emirates Airlines trolley carts took \(1 \frac{1}{2}\) hours to wash by 2 machines. 12 Continental Airline trolley carts took 1 hour to wash. Despite the slow process, 10 trolley carts of British Airways only took 5 minutes to be washed because they used disposal utensils which were not required to wash and can be chucked into the blue bins. Washing of napkins and towels were outsourced (see Figure 31).
2.11 Bonded Warehouse

As well as food, they also supply duty free liquor, tobaccos, perfumes and other gifts. These are supplied from their bonded stores, which is an area that is governed by HM Customs & Excise which they can check their facilities and paperwork at any time.
A Case Study on Flight Catering Company C

By Yevvon Yi-Chi Chang
Flight Catering Company C

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<tr>
<td>22</td>
<td>Recycling plastic bottles</td>
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</tr>
<tr>
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The author would like to thank all Flight Catering Company C staff for their help, in particular, Astrid Brömsen. All errors and omissions remain the responsibility of the author.
1. Company Background

Flight Catering Company C belongs to the air catering division of a larger conglomerate group, which employed over 1500 staff in 2005 in Germany and operate gastronomic outlets at airports, (Düsseldorf, Köln/Bonn, Münster/Osnabrück, Mönchengladbach), railway stations (Düsseldorf, Köln/Bonn, Aschen) and at the fairs of Düsseldorf and Karlsruhe as well as several event houses in Düsseldorf. The air catering division, with its headquarters at Düsseldorf Airport, employed about 250 staff in 2005 and had worked in the airline catering market for than 30 years.

Flight Catering Company C had a catering service unit situated just about a 500 metres away from Köln/Bonn International Airport. The day-to-day function of Flight Catering Company C was to provide catering services to all charter and schedule flights at Köln/Bonn International Airport. 04 of June 2005, the unit served a total of 11 airlines of which two were their major customers: Air Berlin (AB) and LTU International Airways (LTU). The Flight Catering Company C occupied two floor spaces of 1433 m² (see Figure 1). The current unit was built in year 2000 and was designed to have a capacity of producing 7000 meals per day. However, during seasonal peak periods, the unit could have a capacity in excess of producing 11,900 meals per week for the increased number of holiday makers during peak seasons.
Figure 1 Layout of Flight Catering Company C
2. Descriptive Case Study of Operational Processes

2.1 Two Key Performance Indicators of Management
In order to perform well, had to achieve certain key performance indicators (KPI). The two main KPIs were: meals per hour and labour hours per day. The unit manager, Astrid, further explained how the KPIs worked:

A food related department works towards a meals per hour KPI while the workers who load meals onto the flights, work towards an hours per day KPI. Workers in the kitchen have to achieve 1800 meals per day of labour used. In our unit, we have 14 drivers and they work 20 days a month. Theoretically, I should have 280 (14x20) man hours. I expect the driver to do 3 loadings per day (3 x 280) 840 man hours. During the winter, the loading decreased down to 20 in January, I re-assign tasks for the drivers to make up the hours they are supposed to do. They will take a place in the wash area which does not require much skill. Therefore, on a day-to-day basis, they use KPIs to manage the business. By looking at historical data, the computer system not only assists our company to set KPI targets within budget, but also assesses the performances of our managers. Any manager's primary responsibility is to ensure that a good-quality product is produced before loading into the aircraft in a clean environment within company guidelines.

2.2 Functional Flexibility and Temporal Flexibility
By June 2005, Flight Catering Company C had a total of 48 staff. Based on schedules generated by the operation department, the working hours varied for each department. For instance, the dish packing and food assembly departments were divided into 2 shifts, with 10 workers for each shift. One shift started from 06:00 to 15:00 and the other shift from 12:00 to 21:00. Night shifts operated from 21:30 to 05:50 during the summer period. The average working hours was 9 hours per day and included a 1 hour break. In the washing area, the operation was divided into summer and winter programmes as shown in Table 1.
Table 1 The shift patterns for the washing area during summer and winter periods

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>3 days of 2 shifts, handled by 2 workers 06.00 - 15.00 and 14.00 - 22.00</td>
<td>7 days of 1 shift handled by 2 workers 10.00 - 19.00</td>
</tr>
<tr>
<td></td>
<td>4 days of 1 shift handled by 3 workers 10.00 - 19.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 days of 1 shift handled by 2 workers 10.00 - 19.00</td>
<td></td>
</tr>
</tbody>
</table>

Functional flexibility was clearly exhibited in Flight Catering Company C during the summer. They recruited some temporary employees to supplement a smaller core of full time employees, thereby increased the productivity to meet the rise in demand. To ensure all staff gave their best towards achieving the company’s long and short-term objectives, Flight Catering Company C provided a half day training course which consisted of the company induction course, hygiene, fire safety, and all the compliance trainings. The swap of workers was normally within the same process. For instance, to cover shortage of workforce, they would take a tray assembly worker and maybe put them into cold assembly or the despatch department. The cross functionality of workers in Flight Catering Company, was highlighted by Astrid:

> During the winter, on or around the 28th of October, business is like dead. If there is not enough work for drivers during winter, they will do the washing up. If there is not enough work for cabin-packing workers, the drivers will do cabin packing. The workers who work in the cabin packing will go into the kitchen to do assembly if there is shortage of labour there. That’s how I arrange the schedule for my employees.

2.3 Information Technology Implementation of Material Requirement Planning
The communication medium between flight caterers and airline companies becomes a significant tool to fight time and money with other competitors in this business. Internally, Flight Catering Company C had a computer system which helped them to build airline schedules. The system utilised a software package, known as “X-Net”, which managed the flight schedules and predicted the food requirements for each flight. The computer system had a menu costing where each menu could be further...
broken down to its component parts and thereby, able to generate a corresponding forecast of the cost on a daily basis.

The forecasting of quantities and qualities of ingredients was achieved by stating the menu specification agreed with the airline company, where the procurement of raw materials and ingredients could be estimated. Within the menu specification, there were details containing meal description, menu rotation, product code, entrée and recipe. The standard recipe was an essential component in the forecast of raw materials for flight food production. For instance, Air Berlin economy meals of entrée: 10 gm of ham, 20g of cheese and one coriander leaf. Hence, if a flight had 200 economy class passengers, Köln had to place 2000g (200 x 10) of ham and 400g (20 x 200) of cheese from suppliers. The combination of the knowledge of the flight schedule and recipe details was the advanced information for Flight Catering Company C to forecast and reduce inventory stock (see Figure 2).

**Figure 2 Menu specifications**

With X-Net, the production manager could edit the amount of component parts. For example, if the computer read 2.16 kg for butter on the AB 716 flight, but in actual fact there was only 0.015 kg left, he could edit it to reflect the true current amount. This was how the purchasing forecast was planned, which helped them to minimise any waste that arose from unnecessary over-stocking. Therefore, the X-Net is an essential tool that not only helped in planning forecasts but also in placing orders with suppliers based on the forecasted data (see Figure 3). The use of X-Net system indicated there was MRP (Material Requirement Planning) implementation in Flight Catering Company C to assist the elimination of waste. In addition, the employment
of MRP further suggested Flight Catering Company C used a Pull-system instead of a Push-system. Traditional manufacturing plants use a push system where production schedules are developed for maximum capacity based on sales forecasts pushing materials downstream.

Figure 3 List of X-Net contents

Apart from knowledge of the menu specification, the accuracy in forecasting was also dependent on other information, such as passenger figures and last minute orders. In Flight Catering Company C, the operation department was the day-to-day contact that dealt with operational changes, live operations, off schedule flights, flight diversions and also the recipient of passenger figures on a daily basis. Figure 4 showed the work flow of Flight Catering Company C, where the operation department was the first point of contact and information was disseminated from there to other departments.
Hence, the operation department knew how many meals to produce for each flight. They generated figures pertaining to information that included the number of meals to be produced (crew, passenger and special meals) and flight schedules (estimated arrival and departure time). This piece of information is known as the 'Aircraft Allocation Report' (see Figure 5).
Figure 5 Aircraft allocation report

The internal flight figure was generated by the operations officer and made available for the next morning so that each team manager could collect a copy of the production flight figures for the preparation of the day’s schedule. Hence, the workers in hot kitchen and assembly area were actually preparing for tomorrow’s flights based on today’s flight figures (see figure 6).

Figure 6 Internal flight figures that allowed workers in hot kitchen and assembly area to prepare for tomorrow’s flight schedules

2.4 Goods Inward
In total, Flight Catering Company C had 10 suppliers who supply ingredients and materials and 30 duty free suppliers. Delivery of goods was continuous from morning till night. Goods received documents were passed to the stores team who then checked all items that arrived at the unit. The inspection of items was facilitated by a report generated by X-Net that had details on what the opening stock of each individual product was, how many they received in one month, what was the closing stock and
what the items were actually used for. Besides the obvious check of product type and quantity, the stores team would also check for quality and for chilled items. In addition, they will check the temperature of food items, especially for cheese and ham. Any items that failed to reach the agreed standards or were not within the correct temperature guidelines were rejected and returned to the suppliers. The storeman then separated the goods accordingly to dry items, wet items and frozen items. Dry items were obviously food items such as coffee bag and butter that could be stored for very long periods of time and not required to be frozen to keep fresh. Certain items were chilled in order to ensure freshness. These included items like yogurt, milk, fresh vegetables and fruits. Items with a relatively shorter lifespan like meat, were frozen to keep them fresh. On the day of audit in 05 of June 2005, 28 dry items were recorded in the dry store and 40 different chilled items were stored in the fridge (see Figure 7).

Figure 7 Different items in store

In addition to different classifications of food, items for the same flight schedule were labelled for easy identification so as to facilitate collection by other departments for processing. On a ‘first in first out’ concept, different coloured stickers represented different days of the week. For instance, white sticker was used to represent Saturday, pink for Friday, blue for Thursday, green for Wednesday, orange for Tuesday, and yellow for Monday.

2.5 Food Production

Despite the fact that no hot meals were actually produced by Flight Catering Company C, the unit was still capable of providing various special meals for different airlines. There were altogether 25 different types of special meals and included: diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non-dairy, high fibre, bland and low protein meals. In the food
production department, the task of preparing special meals was aided by a booklist that showed all the ingredients allowed in a special meal. This made preparation of special meals easy to follow. Ordering of special meals could be placed through the passenger’s travel agent at the time of booking. The airline would advise Flight Catering Company C at the time of ordering, all meals for a particular flight. This normally happened 24 hours prior to flight departure. In the case of a last minute request for example, one additional diabetic meal, Flight Catering Company C used other ingredients to replace any high sugar content items and avoided the use of any cakes, chocolates, jams or syrups (see Figure 8).

**Figure 8 Diabetic meal specifications**

Flight Catering Company C ensured they had enough products to cover passengers’ special requests by conjuring up meals using standardised food items that satisfied the specific meal requirement. For instance, apart from using plain chicken in regular hot meals, it could also be used for low fat, diabetes, low cholesterol as well as childrens’ meals. These types of special meals were produced using the airlines normal menu as a guideline and adapting the products to suit the specific requirement. Special meals were always clearly labelled with the passenger’s name to make sure the correct meal type was passed to the right person. The only request that Flight Catering Company C could not fulfil were Kosher meals, due to the fact that the unit never produce this type of meal.

The Flight Catering Company C not just had to produce a certain set of menus, they had to change menus from time to time. For charter flights, meals were provided for a set period in time. Every airline rotated their menus for various times of the year, with
most airlines changed their menus monthly. The Kitchen Manager, Rainer, described
the menu rotation process for some of their customers:

For the UPS air cargo meal, we provide 20 types of menus for them to
choose from. Some of the customers, like Ford have a requirement for 3
rotations, and Air Berlin has a requirement for 4 menu rotations as show
in the following example (see Table 2):

Table 2 An example of how the menu was rotated throughout the year

<table>
<thead>
<tr>
<th>Cycle</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>July</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

2.6 Food Assembly

2.6.1 Dish Packing

Before the prepared items were assembled into meals, the items were retrieved from
fridges and assembled in accordance with the specification and photographs of menus.
All items were labelled with a colour-coded sticker that clearly identified the day of
production. The dish packing, tray setup and trolley assembly areas were all situated
in the production area and located in the centre of the kitchen unit, for the convenience
to receive any items from different departments for assembly. In total, approximately
11,900 dishes were packed in a week.

2.6.1.1 Economy Class Dish Packing

There are a number of methods of assembling meals – table-top, conveyor belt or
cellular. In Flight Catering Company C, dish packing was done using the table-top
with various numbers of workers working at the table. The pictures in Figure 9
showed 3 workers assembling cold dishes for Air Berlin using a table-top. First, one
worker laid out 100 plates onto the table, while the second worker put the lettuces
onto the plates. At the same time, the third worker placed 2 slices of cheese onto each
plate. The dish packing workers then took turns to put the rest of the smoked ham and
butter onto the plates, after which they covered the container with a plastic lid and
labelled with a sticker. The whole operation took 1606 seconds (27.16 minutes) to
complete 100 courses with 5 items and included the time taken to load the completed meals into the bulk cart.

**Figure 9 Workers performing cold dish packing for Air Berlin on a table-top**

For Ford Motor Company (Ford) E/C cold dish packing, the meals were assembled using a table-top with 3 workers too. First, one worker laid out 16 plates onto the table while the second worker put the lettuces onto the plates. At the same time, the third worker put smoked ham onto the plates. The dish-packing workers then took turns to place the rest of the ham, meatball, butter, parsley and cherry tomato onto each plate. In total, 16 cold dish packings with 8 items were completed in 630 seconds (10.30 minutes). This included cutting the cheese into half and filming the completed plates. The same process with 8 items for International Airways (LTU), took 452 seconds (7.32 minutes) for one worker to assemble 7 plates.
2.6.1.2 Business Class Dish Packing

Dish packing for business class meals required more skills. The process began with an worker loading each food item onto the main course plate and checked that the presentation layout satisfied the requirement. Hence, the whole process took longer time to complete than dish packing for economy class meals. On the day of audit, an worker took 660 seconds (11 minutes) to prepare 16 business class main courses of 4 items using a table-top, for International Airways (LTU). She scooped the greek salad, placed the chicken breast, parsley and cream sauce onto the plate. All the business main courses were assembled on the table-tops which were separated from economy class meals in the production area (see Figure 11).

Figure 11 Workers performing dish packing for LTU business class cold dishes on a table-top
Table 3 below summarised the average labour time spent on dish packing for each economy and business class meals.

**Table 3 The average labour time for dish packing E/C and B/C meals**

<table>
<thead>
<tr>
<th>Dishing</th>
<th>Assemble Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average Labour Time (per person) for Each Dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/C Air Berlin cold meal</td>
<td>Table top</td>
<td>3</td>
<td>5</td>
<td>5.35 seconds</td>
</tr>
<tr>
<td>E/C Ford cold meal</td>
<td>Table top</td>
<td>3</td>
<td>8</td>
<td>13.1 seconds</td>
</tr>
<tr>
<td>E/C Ford cold meal</td>
<td>Table top</td>
<td>1</td>
<td>8</td>
<td>64 seconds</td>
</tr>
<tr>
<td>B/C LTU cold meal</td>
<td>Table top</td>
<td>1</td>
<td>4</td>
<td>41.25 seconds</td>
</tr>
</tbody>
</table>

2.7 Tray Setup and Trolley Assembly

A conveyor belt was employed in the Flight Catering Company C to perform tray and trolley assemblies. However, the unit manager, Astrid, lamented on the amount of time taken to set up the conveyor belt for each different airline:

> *We have quite a few different airlines and that’s our main problem. If you only have 1 carrier, then it’s very easy. You always repeat the same process and you have to fit the conveyor belt just once. In that case, if you have 10 aircrafts, you just start the conveyor belt and off it goes. But we have so many different airlines and it takes a lot of time to reset the conveyor belt. That’s very time consuming. In our unit, we are trying to assemble the same airlines at one go if the departure time is very close.*

2.7.1 Economy Class Meal Tray Setup and Assembly

Figure 12 showed three workers assembling an Air Berlin economy breakfast on a conveyor belt. They took 360 seconds (6 minutes) for 16 trays that consisted of 4 items (main course, cutlery, desert, and appetiser) plus the time taken to load them into the trolley cart. All the workers stood at the same side of the conveyor belt, facing the food item’s basket assembly. In a two-handed fashion, they placed items onto the trays as they passed by. Firstly, one worker put the main course onto the tray, while the second worker put dessert and appetiser. The last worker then put the cutlery and
the completed trays were loaded onto the trolley cart. On each trolley cart, there was a list, attached on the cart door, indicating the quantity and type of meals.

**Figure 12 Workers performing tray assembly for Air Berlin E/C meal on a conveyor belt**

Another example of tray assembly process was shown in figure 13, with three workers allocated to assemble LTU economy class meals on a conveyor belt. The first worker put the sandwich onto each tray, while the second worker put the juice and yogurt. The completed trays were then loaded by the last worker into the trolley cart. In total, the whole process to complete and load 16 tray setups of 3 items (sandwich, yogurt and juice) into the trolley cart, took 240 seconds (4 minutes).

**Figure 13 Workers performing tray assembly for LTU light meals on a conveyor belt**

Again, figure 14 showed four workers assembling Air Berlin economy breakfast on a conveyor belt. The first worker placed the main course and side plate onto the tray, with the second worker putting desert and yogurt; while the third worker put the cutlery and jam. Finally, the task of the last person was to load the completed trays into trolley cart. They took 400 seconds (6.4 minutes) to assemble 16 trays that
consisted of 6 items (side plate, main course, desert, yogurt, cutlery and jam) plus the
time to load them into the trolley cart.

Figure 14 Workers performing tray setup for Air Berlin breakfast on a conveyor
belt

2.7.2 Business Class Meals, Crew Meal Tray Setups
In addition, the table-top method was used for LTU first class tray set assembly. In
figure 15, one worker was shown to assemble one at a time, 5 trays of 8 items that
consisted of coffee cup, cutlery, butter, wine glass, wine, cold course, dessert, fruit
and cheese. She completed within 200 seconds (3.3 minutes) with good presentation
layout.

Figure 15 A worker assembling LTU first class meal tray setup

For the European Air Express (EAE) crew meal, one worker assembled 3 trays in 30
seconds, which included the time taken to load them into the trolley cart. Each tray
had 5 items consisting of cup, spoon, banana, soup, and chocolate (see Figure 16).
On the day of audit, the total number of tray setups consisted of 1936 E/C charter flight trays, 300 schedule flight trays, 50 first class tray setups and 120 crew trays. In general, the average labour time for each economy class tray setup took 1.2 to 1.83 seconds, and the average labour time for first class tray setup and crew meal took 10 and 40 seconds respectively; depending on the number of different items that was required to be loaded onto the tray (see Table 4).

### Table 4 Average labour time spent on tray setup and trolley assembly for E/C and B/C meals

<table>
<thead>
<tr>
<th>Tray Setup and Trolley assembly</th>
<th>Assembly Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each tray setup and trolley assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Berlin E/C</td>
<td>Conveyor belt</td>
<td>3</td>
<td>4</td>
<td>6 seconds</td>
</tr>
<tr>
<td>LTU E/C light meal</td>
<td>Conveyor belt</td>
<td>4</td>
<td>3</td>
<td>5 seconds</td>
</tr>
<tr>
<td>Air Berlin E/C breakfast</td>
<td>Conveyor belt</td>
<td>4</td>
<td>6</td>
<td>6.25 seconds</td>
</tr>
<tr>
<td>Air Berlin E/C breakfast</td>
<td>Conveyor belt</td>
<td>4</td>
<td>6</td>
<td>6.56 seconds</td>
</tr>
<tr>
<td>LTU first class</td>
<td>Table top</td>
<td>1</td>
<td>8</td>
<td>40 seconds</td>
</tr>
<tr>
<td>EAE crew meal</td>
<td>Table top</td>
<td>1</td>
<td>5</td>
<td>10 seconds</td>
</tr>
</tbody>
</table>

#### 2.8 Despatch and Loading Areas

Once the workers had completed the food assembly process, they sent the trolley carts to the despatch area. Each trolley cart took about 20 seconds to transport from the food assembly area to the despatch area, which was relatively near. In Flight Catering Company C, the food was produced during the day and today’s production schedule was for preparing tomorrow’s flights. Therefore the food had to be stored in the fridge at least 2 hours before loading time. Generally, the food was produced 12-15 hours
before flight departure. As a result, the trolley cart’s door was opened to keep the food cool (see Figure 17). Quality checks on food were conducted by lorry drivers before being loaded onto the refrigerated vehicle and then transported to the aircraft. In addition, the daily newspapers provided by airline companies also had to be loaded onto the aircraft. Flight Catering Company C had a transport fleet of five 3.5 tonnes trucks and a total of 14 drivers. The work schedule varied for the drivers, depending on the charter flight schedule. Each driver in general, had to work 3 loadings per day.

Figure 17 Despatch fridge and loading Area

The used trolley carts unloaded from the aircraft had to be uploaded into the truck before the newly assembled trolleys were loaded onto the aircraft. The driver then conducted a final check on the entire catering requirement for each flight, based on the flight figure generated by the operations department.

2.9 Equipment Area

In the equipment store, there were a total of about 600-900 items. Items are coded to assist the management for easier identification of the number of stocks they had for each item. For instance, there should be at least 38 coffee pots for Air Berlin on the shelf and if the number was less than 38, the storeman immediately informed the warehouse to adjust for the shortage. (see Figure 18).
Each airline would supply their own equipment. It was the responsibility of Flight Catering Company C to store, clean and manage these equipment. A stock count on the equipment was conducted every month. If there happened to be shortage in equipment, they would get the necessary item from the warehouse. If it was found that there was no stock for that particular equipment in the warehouse, they would contact the airline company to request the item in order to make up for the shortage. The equipment department supplied all the cutlery, salt and pepper, before sealing them into the trolley cart (see Figure 19).

2.10 Washing Area
Figure 20 showed the working process in the washing area, where the trays were unloaded from the trolleys then transferred by hands onto the conveyor belts associated with the washing system. At the end of the washing conveyor belt, one worker was assigned to sort the different equipment items into baskets. The temperatures for pre-wash, wash and rinse cycles was not to be lower than 48 degrees
The washing system had special wash tunnels for trolleys as well as for crockery, trays and other special baskets.

**Figure 20 Washing machine temperature inspection**

All kinds of recyclable items such as cutlery, cups, trays and crockery were washed on the conveyor belt washing machine (see figure 21). To avoid messing up all the equipment, they washed everything associated with the same airline all at the same time. Heavily stained cups or plates were soaked in white plastic bins with cleaning agents which were then washed again. Once all the equipment had been washed, the storeman then came to collect them and sent them back to the equipment store. Any waste food from the trays was put into one compactor and 4 blue bins. In total, 10% of the equipment were non-disposal items like plastic cutlery, while 90% of the equipment to be washed were non-disposal items for instance, glassware items. All disposal equipment was thrown into the blue bins.
During peak times, equipment unloaded from the aircraft; occupied a lot of space in the washing area while waiting to be processed. Therefore, the number of work shifts in the washing area was adjusted to meet the demand - morning shift and night shift if necessary. In consideration of hygiene factor, the unwashed trolley carts were stored in the chiller to eliminate the smell. Figure 22 showed two workers standing in front of the machine to upload the trays and cups onto the belt. Waste food was thrown away in blue bins, and all the bottles, cans, glasses and paper were stored for further recycling. There were two waste storage places in Flight Catering Company C, which were categorised into either paper or bottle storage. The supplier would come to collect the recycled items and pay for each recycled bottle (see Figure 22). On the day of audit, 1700 trays were washed. Apart from the initiative to reduce waste by recycling equipment, there was another reason why waste management was so important in Flight Catering Company C. The German government laid down waste management regulations for all caterers to adhere to, otherwise caterers faced a fine or warning and the possibility of closing down by the government.
Figure 22 Recycling plastic bottles

2.11 Bonded Warehouse
Apart from food items, Flight Catering Company C also supplied duty free liquor, tobaccos, perfumes and other gifts from their bonded stores. Figure 23 showed 3 workers assembling the duty free cart based on the airline request list. The duty free carts were then sealed and delivered to the despatch area (see Figure 22).

Figure 23 Bonded warehouse
A Case Study on Flight Catering Company D

By Yevvon Yi-Chi Chang
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1. Company Background

Flight Catering Company D belongs to the air catering division of a larger conglomerate group, which employed over 1500 staff in 2005 in Germany and operate gastronomic outlets at airports, (Düsseldorf, Köln/Bonn, Münster/Osnabrück, Mönchengladbach), railway stations (Düsseldorf, Köln/Bonn, Aschen) and at the fairs of Düsseldorf and Karlsruhe as well as several event houses in Düsseldorf. The air catering division, with its headquarters at Düsseldorf Airport, employed about 250 staff in 2005 and had worked in the airline catering market for than 30 years.

Flight Catering Company D had a catering service unit situated about 2 miles away from Leipzig/Halle International Airport. The day-to-day function of Flight Catering Company D was to provide catering services to all charter and occasional VIP flights travelling in and out of Leipzig/Halle and Dresden International Airports. At the moment, the unit served a total of 16 airlines, of which two are their main customers: Air Berlin (AB) and LTU International Air (LTU). Flight Catering Company D occupied two floor spaces of 709 m² (see Figure 1). The current unit was built in year 2002 and was originally designed to have a capacity of producing 7000 meals per day. However, due to the increased number of holiday makers during peak seasons, the unit could produce in excess of 17,500 meals per week by employing more temporary staff.
Figure 1 Layout of the Flight Catering Company D
2. Descriptive Case Study of Operational Processes

2.1 Two Key Performance Indicators of Management
In order to perform well, Flight Catering Company D had to achieve a key performance indicator (KPI), which was the targeted number of completed meals per hour. The unit manager, Peter, further explained:

*We set our KPI to be 2000 meals per day of labour used. On a day-to-day basis, KPIs are used to manage the business by looking at historical data. The computer system not only assists our company to set KPI targets within budget, but also assesses the performance of our managers. Any manager’s primary responsibility is to ensure that a good-quality product is produced before loading onto the aircraft in a clean environment within company guidelines.*

2.2 Functional Flexibility and Temporal Flexibility
Flight Catering Company D unit had a total of 28 staff. Working hours varied for each department based on flight schedules generated weekly by the unit manager. Prior to the generation of the flight schedules, the unit manager would discuss with each department’s head to reach an agreement for the working hours of each department’s staff. The weekly working hours were planned 2 weeks in advance. Dish packing and food assembly was divided into 2 shifts with 9 workers. One shift operated from 05:00 to 13:30, and the other shift from 16:00 to 00:30. The average working hours were 8.5 hours per day and included a 30 minutes break. During the break, the production manager or one of the workers would set up the assembly equipment. As for the washing department, workers were divided into 2 work shifts (05:00 to 13:30 and 16:00 to 00:30) with 2 workers in each shift. In the event of any shortage in workforce, drivers from the despatch department would cover the workload of the stores area by receiving goods or the unskilled task of washing up in the washing department. Sometimes, they would take a tray assembly worker and put him/her to the cold assembly or despatch department to supplement the workforce there.
Functional flexibility was clearly exhibited in Flight Catering Company D. During summer, they recruited some temporary employees to supplement a smaller core of full time employees to increase productivity in order to meet the rise in demand. To ensure all staff gave their best toward achieving the company’s long and short-term objectives, Flight Catering Company D conducted a 3 hours of training that included an induction course, hygiene, fire safety, and all the compliance trainings for all staff.

2.3 Information Technology Implementation of Material Requirement Planning

The communication medium between flight caterers and airline companies becomes a significant tool to fight time and money with other competitors in this business. Internally, Flight Catering Company D had a computer system which helped them to build airline schedules. The system utilised a software package, known as “X-Net”, which managed the flight schedules and predicted the food requirements for each flight. The computer system had a menu costing where each menu could be further broken down to its component parts and thereby, able to generate a corresponding forecast of the cost on a daily basis.

In Flight Catering Company D, they had adopted the method of MRP to eliminate unnecessary waste. The forecasting of quantities and qualities of ingredients was first achieved by stating the menu specification agreed with the airline company which then enabled the procurement of raw materials and ingredients to be estimated. The menu specification gave details containing meal description, menu rotation, product code, entrée and recipe. The standard recipe was an essential component in the forecast of raw materials for flight food production. For instance, Air Berlin economy meals of entrée: 10g of ham, 20g of cheese and one coriander leaf. Hence, if a flight had 200 economy class passengers, Flight Catering Company D had to place 2000g (200 x 10) of ham and 400g (20 x 200) of cheese from suppliers. The combination of the knowledge of the flight schedule and recipe details was the advanced information for input into X-Net to forecast and reduce inventory stock (see Figure 2).
The implementation of MRP indicated that Flight Catering Company D used a Pull-system instead of a Push-system. Traditional manufacturing plants used a push system where production schedules were developed for maximum capacity based on sales forecast pushing materials downstream. With X-Net, the production manager could edit the amount of component parts. For example, if X-Net read 15000kg of turkey ham for Air Berlin’s flight, but in actual fact there were nothing left in stock; the production manager could edit the amount of this component part as nil to reflect the true amount. This was how the purchasing forecast was planned which helped Flight Catering Company D to minimise any waste. Therefore, X-Net was an essential tool that not only aided Flight Catering Company D in planning forecasts but also in placing orders with suppliers based on the forecast data (see Figure 3).

Apart from knowledge of the menu specification, the accuracy in forecasting was also dependent on other information, such as passenger figures and last minute orders. In Flight Catering Company D unit, the operation department was the day-to-day contact
Flight Catering Company D Descriptive Case Study of Operational Processes

that dealt with operational changes, live operations, off schedule flights, flight diversions and also the recipient of passenger figures on a daily basis. Figure 4 showed the work flow of Flight Catering Company D, where the operation department was the first point of contact and information was disseminated from there to other departments.

**Figure 4 Work flow of the Flight Catering Company D**

Hence, they knew how many meals to produce for each flight. The operation department generated figures pertaining to information that included the number of
meals to be produced (crew, passenger and special meals) and flight schedules (estimated arrival and departure time). The operations officer would generate the production flight figure and made available next morning for each team’s manager to collect, in order to prepare for the next day schedule. Hence, the workers were actually preparing for tomorrow’s flights based on today’s flight figure (see figure 5).

**Figure 5 Internal flight figure**

2.4 Goods Inward
Flight Catering Company D had 7 suppliers who supplied ingredients and materials, and 12 suppliers who supplied duty free products. Delivery of goods was twice a day, from 08:00 to 12:00 and from 13:00 to 15:00. The despatch driver, apart from fulfilling the task of dispatching meals, he was also assigned the task of receiving goods from suppliers. Goods received documents were passed to the stores team, who then checked all items arriving at the unit by tallying with a report generated by X-Net with details on; what the opening stock of each individual product was, how many they received in one month, what the closing stock was and what they were actually used for. Thus, X-Net enabled the stores team to check the product type, quantity and quality of newly arrived goods easily. The stores team also checked the temperature and filled in the Hygiene form, in particular for items like cheese and ham because these items could be contaminated easily. Any items failing to reach the agreed standards or were not within the correct temperature guidelines were rejected and returned to the supplier. The stores team then categorised the goods accordingly to dry items, wet items and frozen items. Dry items were normally stored more than a week and chilled items like yogurt, milk, fruits were stored less than one week. For items like bread and vegetables, they were received every morning to ensure freshness. On
the day of audit, there were 27 different dry items and 34 different chilled items stored in the fridge (see Figure 6)

**Figure 6 Items in store and a list of the hygiene form**

In addition to different classifications of food items, items for the same flight schedule were labelled for easy identification when collected by other departments for processing. On a ‘first in first out concept’, different coloured stickers represented different days of the week, for instance, red was for Sunday, white for Saturday, pink for Friday, blue for Thursday, yellow for Monday, orange for Tuesday, and green for Wednesday.

### 2.5 Food Production

Despite the fact that no hot meals were actually produced in Flight Catering Unit D, the unit was still capable of providing various special meals for different airlines. There were altogether 25 different types of special meals and included: diabetic, gluten free, low cholesterol, low sodium, vegetarian, vegan, Asian vegetarian, Muslim, Hindu, non-dairy, high fibre, bland and low protein meals. In the food production department, the task of preparing special meals was aided by a booklist that showed all the ingredients allowed in a special meal. This made preparation of
special meals easy to follow. Ordering of special meals could be placed through the passenger’s travel agent at the time of booking. The airline would advise Flight Catering Company D at the time of ordering, all meals for a particular flight. This normally happened 24 hours prior to flight departure. In the case of a last minute request for example, one additional diabetic meal, Flight Catering Company D used other ingredients to replace any high sugar content items and avoided the use of any cakes, chocolates, jams or syrups.

In addition, Flight Catering Company D ensured they had enough products to cover passengers’ special requests. These types of special meals were produced using the airlines’ normal menus as a guideline and adapting the products to suit the specific requirement. Special meals were always clearly labelled with the passenger’s name to ensure the correct meal type was passed to the right person.

Flight Catering Company D not only had to produce a certain set of menus, but also had to change menus from time to time. For the charter flights, meals were provided for a set period in time. Every airline would rotate their menus for various times of the year, with most airlines changing their menus monthly. For instance, LTU had 2 menu rotations for summer and winter periods, while Air Berlin had 4 menu rotations as shown in the following example:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 An example of how menus were rotated throughout the year

2.6 Food Assembly

2.6.1 Dish Packing

The next procedure was to assemble the prepared items into meals. The items were first retrieved from fridges and assembled in accordance with the specification and photographs of menus. All items were labelled with a colour-coded label that clearly identified the day of production. The production kitchen was divided into two areas:
one for dish packing and the other area was for tray setup and trolley assembly. The total number of dish packing was approximately 17,500 dishes in one week.

2.6.1.1 Economy Class Dish Packing

There were a number of methods for assembling meals – table-top, conveyor belt or cellular. In Flight Catering Company D, dish packing was done using the table-top with various numbers of workers working at the table. The pictures below (Figure 7) showed 2 workers performing Air Berlin cold meal packing using a tabletop. The first worker laid out 100 plates onto a table and simultaneously, the second worker put the lettuce onto each plate. Afterwards, the first worker put the next item, which was 2 slices of ham onto the plate. Then, the workers took turns to put the rest of the items: cheese, smoked ham and butter, and covered the containers with a plastic lid as final meal presentation. Altogether, the process took 1500 seconds (15 minutes) to complete 100 courses with 5 items, which included the time taken to load them into the bulk cart.

Figure 7 Workers performing dish packing for Air Berlin cold dish on a tabletop

The Air Berlin E/C appetiser dish packing was assembled using the table-top with 2 workers. First, one worker laid out 100 plates onto a table, followed by the second worker who put the lettuce onto the plates. Then, the first worker put the cheese ball onto the plates and covered the containers with a plastic lid. In total, 100 appetiser cold dish packings with 3 items were completed in 750 seconds (7.5 minutes) (see Figure 8).
Figure 8 Workers performing dish packing for Air Berlin appetiser cold dish on a table-top

Figure 9 showed three workers who took 380 seconds (6.2 minutes) to perform layout for 8 LTU International Airways (LTU) E/C sandwich with 5 items on a table-top. The assembly process began with cutting the bread into half size, spreading the mayonnaise onto the toast, put on the lettuce, ham, and cheese and then covered up with a slice of bread. Finally, they were loaded into the sandwich bag and sealed (see Figure 9).

Figure 9 Workers performing dish packing for LTU E/C sandwiches on a table-top

Table 2 below showed the average labour time spent on dish packing for each economy and business class meals.

Table 2 The average labour time for dish packing E/C and B/C meals

<table>
<thead>
<tr>
<th>Dishing</th>
<th>Assembly Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/C Air Berlin cold meal</td>
<td>Table top</td>
<td>2</td>
<td>5</td>
<td>7.5 seconds</td>
</tr>
<tr>
<td>E/C Air Berlin appetiser</td>
<td>Table top</td>
<td>2</td>
<td>2</td>
<td>3.75 seconds</td>
</tr>
<tr>
<td>B/C LTU sandwich</td>
<td>Table top</td>
<td>3</td>
<td>5</td>
<td>15.8 seconds</td>
</tr>
</tbody>
</table>
2.7 Tray Setup and Trolley Assembly

A conveyor belt was employed in Flight Catering Company D to perform tray and trolley assemblies. Their production manager further commented:

To reduce the time for tray set up assembling, one worker or myself will set up the belt and prepare all the items in place before we start assembly. We try to assemble for the same airline company at the same time if possible. Thus, we don’t have to re-set the belt again. The empty trolley cart was lifted up to the same height as the conveyor belt. This makes it easier for our worker to load the tray into trolley cart. We can set up the 4 trolley carts onto the lift at one time.

2.7.1 Economy Class Meal Tray Setup and Assembly

Figure 10 showed four workers assembling Air Berlin economy breakfast on a conveyor belt. It took them 95 seconds (1.58 minutes) for the assembly of 16 trays that consisted of 6 items (side plate, main course, desert, yogurt, cutlery and jam), including the time to load them into the trolley cart. The first worker put the main course and side plate onto the tray, while the second worker put desert and yogurt. Then, the third worker put the cutlery and jam. After which the trays were loaded into the trolley cart by the fourth worker. On the next day of audit, the same workers took 160 seconds (2.4 minutes) for the assembly of 16 trays.

Figure 10 Workers performing tray setup for Air Berlin breakfast on a conveyor belt

Two workers were shown in figure 11, assembling LTU economy class meals on a conveyor belt. The first worker put yogurt and juice onto the tray, one tray at time; while the second worker put sandwich, cutlery and then filled the trolley cart with the
completed trays. The whole process took 170 seconds (2.5 minutes) to assemble 16 tray setups with 4 items.

**Figure 11 Workers performing tray assembly for LTU light meal on a conveyor belt**

![Image of workers assembling trays on a conveyor belt](image1.png)

The conveyor belt was alternatively used, in place of the table-top method, for additional Air Berlin E/C meals. One worker laid 10 trays on the belt at a time and put the cutlery, cake and salad onto the tray. Then, he put them into the bulk box (see Figure 12) and altogether he took 80 seconds (1.2 minutes) for 10 tray setups with 3 items. It was very time consuming to do additional meals because of the need to re-set the belt and to retrieve the food from the fridge or equipment store.

**Figure 12 A worker assembling Air Berlin additional E/C breakfast tray set**

![Image of a worker assembling trays on a conveyor belt](image2.png)

On the day of audit, the total number of tray setups consisted of 1875 E/C charter flight trays. In general, the average labour time for each economy class tray setup took 5 to 5.3 seconds and the average labour time for additional E/C tray setup took 8 seconds (see Table 3).
Table 3 Average labour time spent on tray setup and trolley assembly for E/C meals

<table>
<thead>
<tr>
<th>Tray Setup and Trolley assembly</th>
<th>Assembly Method</th>
<th>No. of Workers</th>
<th>No. of Items</th>
<th>Average labour time (per person) for each tray setup and trolley assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Berlin E/C breakfast meal</td>
<td>Conveyor belt</td>
<td>2</td>
<td>6</td>
<td>5 seconds</td>
</tr>
<tr>
<td>LTU E/C light meal</td>
<td>Conveyor belt</td>
<td>2</td>
<td>4</td>
<td>5.3 seconds</td>
</tr>
<tr>
<td>Air Berlin E/C additional meal</td>
<td>Conveyor belt</td>
<td>1</td>
<td>3</td>
<td>8 seconds</td>
</tr>
</tbody>
</table>

2.8 Despatch and Loading Areas

Food assembly workers sent the trolley carts to the despatch area once they had completed assembly. Each trolley cart took 20 seconds to transport from the food assembly area to the despatch area. In Flight Catering Company D, the food was produced during the day and today’s production schedule was for preparing tomorrow’s flights. Quality checks on food were conducted by despatch drivers before being loaded onto the refrigerated vehicle and then transported to the aircraft.

In total, Flight Catering Company D had 6 drivers, 3 five tonnes trucks and 2 two tonnes trucks. However, the trucks were shared with Flight Catering Company D Dresden where 3 trucks were allocated to the Flight Catering Company D, and 2 trucks for the Dresden unit. The 6 drivers were rotated between 5 shifts that were from 0:00 to 8:30, 22:00 to 06:30, 10:30 to 19:00 and 08:00 to 16:30 and 12:00 to 20:30. The trucks departed from Flight Catering Company D to Dresden twice a day at 10:00 with 900 meals, and at 21:30 with 500 meals. The quantities of trolley carts were also checked by the despatch drivers before leaving the unit to the airport. Duty free carts would be ready and stored in the despatch area for the driver to load into the aircraft. The used trolley carts collected from the aircraft had to be uploaded into the vehicle before the newly assembled trolleys were loaded into the aircraft.
2.9 Equipment Area
The equipment store had nearly 700-900 different items in total. A list of “part level” code of each airline company was used to assist workers to manage the high volume and high variety of equipment items. Each part item in the list was indicated with figures of maximum quantity and minimum quantity. For instance, there should be at least 32 coffee pots for Air Berlin on the shelf and if the number was less than 32, the store man was required to inform the warehouse to top up the shortage in quantity (see Figure 14).

Each airline supplied their own equipment. It was the responsibility of Flight Catering Company D to store, clean and manage these equipment. A stock count was conducted every month for LTU. On the other hand, Air Berlin stock was checked weekly. If there was shortage of equipment, Flight Catering Company D would get the necessary equipment from warehouse and divided everything according to schedule. Alternatively, they emailed the airline company with a request to cover the shortage. The equipment department supplied all the cutlery, salt and pepper, before sealing them into the trolley cart and placed into a fridge (see Figure 15).
2.10 Washing Area

In Flight Catering Company D, one worker unloaded trays from trolleys and transferred them by hand onto the conveyor belts associated with the washing system. The washers had special wash tunnels for trolleys as well as for crockery, trays and other special baskets before being taken to storage locations on trolleys. One worker stood at the end of the washing conveyor belt to sort out the different equipment items and then put them into a basket. It was important that the temperatures for pre-wash, wash and rinse must not be lowered than 66 degrees (see Figure 16).

Figure 16 Washing machine temperature inspection

All kinds of recyclables like cutlery, cups, trays and crockery were washed on the conveyor belt washing machine, while the trolley carts were washed by hand (see figure 17). To avoid messing up all the equipment, they performed wash up for the same airline company at the same time. For heavily stained cups or plates, they would soak them in white plastic bins with cleaning agents and re-washed them again. Once all the equipment had been washed, the workers sent them back to the equipment store. Any waste food from the trays were then put into one compactor and 4 blue bins. 10% of the equipment were non-disposal items like plastic cutlery, while 90% of
the equipment to be washed were non-disposal items for instance, glassware items. The disposal equipment were all thrown into the blue bins.

**Figure 17 Washing area**

During peak times, equipment unloaded from the aircraft occupied a lot of space in the washing area while waiting to be processed. Therefore, the number of work shifts in the washing area was adjusted to meet the demand - morning shift and night shift if necessary. In consideration of hygiene factor, the unwashed trolley carts were stored in the chillier to eliminate the smell. Figure 18 showed two workers standing in front of the machine to upload the trays and cups onto the belt. One worker stood at the front of the machine to upload the tray and cup, while the other person stood at the end of the belt to put the washed trays and cups into the basket. In total, 3200 trays and 6000 side plates were washed in a day. The waste foods were thrown away in the blue bins, and all bottles, cans, glasses and paper were recycled in the waste storage. The supplier would come to collect the recycled items where refunds were given for each bottle returned (see Figure 18). Apart from the initiative to reduce waste by recycling equipment, there was another reason why waste management was so important in Flight Catering Company D. The German government laid down waste management regulations for all caterers to adhere to, otherwise caterers faced a fine or warning and the possibility of closing down by the government.

**Figure 18 Recycling plastic bottles**
2.11 The Bonded Warehouse
Besides supplying food, Flight Catering Company D also had a bonded warehouse that supplied duty free liquor, tobaccos, perfumes and other gifts. Figure 19 showed 3 workers assembling the duty free cart based on the airline request list. All the duty-free carts were sealed and delivered to the despatch area (see Figure 19).

Figure 19 Bonded warehouse

Flight Catering Company D had a catering instruction manual (CIM) that showed the quantities of duty free items. The bar cart was required to be loaded with the items as shown in the CIM. For instance, container A of the bar cart needed to be loaded with 5 bottles of orange juice, apple juice and tomato juice, while container F loaded with cigarettes, for a typical non-European flight (see Figure 20).

Figure 20 The catering instruction manual