Study of Managing and Developing Procedures to Calculate the Retail Packaging Waste in New Zealand.

A thesis presented in fulfilment for the degree of:
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Abstract

The purpose of completing this research is to develop a system that will estimate the total volume of retail packaging in our waste streams. The research also outlines the procedures that are required in order to complete the project in future years. The objectives of the project were to complete a thorough investigation into the following fields of literature; Packaging Fundamentals, Sampling Statistics, Regression Analysis and project management to assist in developing a sound methodology to collect data.

Woolworths. Pak N Save. The Warehouse and Liqour King stores were used, as it was believed that these stores would most fairly represent the retail market. The Warehouse in general merchandise, the 2 grocery stores as the food market and the bottle store as one of the foremost users of packaging innovation in the retail market.

The largest step of this project was collecting the data. Unfortunately not each piece of retail packaging can be assessed so this project was implemented to rationalise this sample to an accurate and reliable representation of the retail market. Then using a simple net gross weight methodology assess a proportion of the packages to develop conversion equations. Once the conversion equations were developed then these could be applied to all the packages. Secondary Packaging was also assessed but using a slightly different process that investigated the recycling of cardboard from all the stores.

This information can then be extrapolated up to represent the complete and entire retail market. This was done on a market share basis. For example Woolworths represent 30% of New Zealand's grocery market. Therefore the weight and volume of packaging from that store could be extrapolated up to represent the complete grocery market.

From this, a procedures manual and a future plan was outlined in order to maintain up to date information.

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Chapter 1. Introduction and Background

1.1. Background: Packaging Council of New Zealand Inc.

The Council was formed in 1992 at the request of Government and has, in the last nine years, established a good working relationship with the Ministry for the Environment and other Government sectors. The Council strives to ensure that the New Zealand packaged goods industry addresses, on a voluntary basis, those issues relating to packaging usage and waste which have, in many other countries, resulted in legislative actions with costs to both producers and consumers.

In 1996, the Council was successful in establishing an ACCORD with Government on behalf of industry aimed at minimising the adverse environmental effects of unwanted packaging. This is a voluntary process which the majority of major manufacturers and fillers of packaging have supported and was reached after research into the role of packaging in the New Zealand waste stream and a subsequent negotiation with Government.

The Council's ongoing work is to monitor the role of waste packaging in the New Zealand waste stream, ensure that the volume remains at an acceptable level minimising the need for restrictive legislation.

Fundamental to the work of the Council is the establishment of a nation-wide education programme that puts into perspective the role of packaging in a modern society. The Council's research has established that packaging is less than 12% of the municipal waste stream and it is clear that the spoilage prevented by the use of appropriate packaging is greater than the waste packaging created once it is no longer required (New Zealand Packaging Council Website, 2001). The Council recognises that to be successful the role of packaging must be promoted and in perspective. To this end it has worked in concert with Central and Local Government in the production of appropriate educational material.

The current membership of the Council continues to increase with most major companies involved in packaging participating. The Council has an ongoing membership drive to more extensively meet its and Central Governments objectives with greater national involvement.

Of primary importance is the ongoing research carried out to accurately establish the incidence of indirect imported packaging on the New Zealand retail shelves and the establishment of an Awards programme for Environmentally Acceptable Packaging.

On a regular basis the Council conducts mass balances, including recovery rates, for the five principal material types used in packaging and also monitors the light-weighting and down-gauging of packaging materials.

The Council personnel also conduct lectures and prepare articles for the media.

The Packaging Council's main objectives are to:

- represent manufacturers, fillers, wholesalers, retailers and consumers of packaging
- provide a holistic approach to the issue of packaging waste
- keep key players in government, industry and the community informed about packaging

The Council was set up to provide information about the environmental effects of packaged goods, waste packaging, and waste materials collection, recycling, reuse and residual management and to initiate voluntary action addressing the issue of packaging waste across the product chain from raw materials to retail sales.

As a key player in reporting and discussing packaging issues with the government the Packaging Council need regular updated information as to what the trends in packaging usage, not only from the manufacturers but from the end user and the stores that manage the products. Hence the Packaging Council need's reliable information about the retail volume manufactured, consumed, recycled locally and also volumes that are imported from various countries.

The Packaging Council requires information on the exact quantity or proportion of imported packaging in the New Zealand retail sector. In 1998 students from Waikato Universities Marketing Department completed a project that measured the total volume of imported packaging in the New Zealand retail sector. Their solution was within 5% of the expected volume that was generated from manufacturers of packaging in New Zealand. However there was some concern raised over the volumes of specific materials. Some of the volumes for the various materials were over 20% out from what was predicted. (PCNZ, 2000)

To ensure that their data was up to date the amount of imported retail packaging requires checking regularly.

1.2. Packaging Background

The most obvious benefit of packaging is to preserve and protect foodstuffs and all other consumer goods from damage and spoilage. Packaging also plays an important role in the containment of a product, the communication of information to the purchaser of the product and recently the convenience and performance of the product. One international study found that the loss of foodstuffs between grower and consumer is about two percent in the developed world and up to 33 percent in the developing world. The difference is largely due to incorrect or badly designed packaging. (PCNZ, 2000)

Packaging makes up less than 12 percent by weight of the New Zealand municipal waste stream. Recycling and lighter weight packaging have reduced potential packaging waste volumes by more than 40 percent over the past 12 years. (PCNZ, 2000)

There are many misconceptions about the amount of waste caused by packaging. This has been caused by, consumers creating informal data believing that package content in the landfill is equivalent to the volume they dispose of in their rubbish bags. The informal and misleading data estimates this packaging waste to be 80-90%. (Robertson, 2001)

In actual fact, lightweight materials and improved designs have led to big reductions in the weight of product packages over the past 10 years. The Packaging Council estimates that the packaging industry has reduced the unit weight of packages by more than 20 percent in the past 12 years. (PCNZ, 2000)

1.3. Project Aim

To develop and use a sampling based system that will:

- Estimate the total volume of retail packaging in New Zealand based on a sample population of The Warehouse, Liquor King, Woolworths and Pak N Save.
- Estimate the percentage of packaging that is imported and what percentage is New Zealand made.
- Estimate the proportions of each of the following packaging materials:
    - Paperboard
    - Plastics
    - Glass
    - Steel or Tin
    - Aluminium

The system must include a procedure manual that guides future project operators through the following:

- Guides as to what information is required
- Steps to complete the data collection
- Steps involved in the conversion to weight process
- Steps involved in the data analysis

- A comprehensive list of conversion equations and conversion rates.

1.4. Objectives

The objectives of this project were to:

- Gain an understanding of the key elements of:
    - Project Management
    - Packaging Materials
    - Statistical Sampling and Statistical Analysis
- Put the understanding of project management into practise and develop a sound project plan
- Put the understanding of sampling and statistical information and develop a sampling methodology that will decrease the expense of financial and human resources
- Design conversion equations and/or conversion rates for all the packaging materials involved in the retail market
- Put the methodology and conversion rates designed into practice, continually analysis and improving them as the project progresses.
- Analyse the output of the process and conversion rates and present the results based on the aims of the project.
- Prepare a procedure manual that will clearly define the steps necessary to complete this project in subsequent years
- Present the information and the manual/s to the Packaging Council of New Zealand Inc.

1.5. Description of Main Areas of research

1.5.1. Project Management

In order for this project to be successful, an up to date and detailed understanding of project management was needed. This thesis looks at the introduction and description of these methods and then describes the way that the most suited tools were put into practise.

1.5.2. Packaging Materials

A detailed understanding of all the packaging materials was needed. This thesis looks into the materials that are most commonly used and how they can be sampled, identified and have their weights estimated. A brief investigation into packaging materials specific technologies and retail use is also explained.

1.5.3. Sampling and Statistical Interpretation

Sampling and statistical interpretation also played a large role in this thesis. Sampling methodologies, techniques, descriptive statistics and regression analysis are all researched and detailed in this report. A culmination of these areas of statistics was used to produce the required results set out in the aims of the project.

1.6. Summary

This chapter introduces the main areas of research of the thesis. This chapter also provides an insight into the role of the Packaging Council of New Zealand and the general role of packaging. The aims and objectives of this assignment are clearly defined. The remainder of the thesis is the research that took place in order to complete these aims and objectives.

Chapter 2. Literature Review

2.1. Project Management

2.1.1. Introduction: Definition of Project Management.

Project Management has evolved in order to plan, co-ordinate and control the complex and diverse activities of modern industrial and commercial projects. All projects share one common characteristic, the projection of ideas and activities into new endeavours. The ever-present element of risk and uncertainty means that the time to complete the events and tasks leading to the completion of a project can never be forecasted with an absolute accuracy.

The purpose of project management is to foresee or predict as many dangers and problems as possible to plan, organise and control activities so that the project is completed in spite of the risk that are taken. This process starts before any resources are committed, and must continue until all the work is finished. The aim of the project is that the final result will satisfy the project sponsor and any other stakeholders involved within a certain time scale and without using more money and other resources than those that were originally set aside or budgeted.

It is also important to understand that there is more to the practise of successful project management than the application of a few sophisticated computer programmes. It embodies a whole framework of progressive management planning, monitoring, decision-making and clear documentation. (Lock, 1997)

Smith (1997) perceives projects in four very separate ways. A project can be:

- A sequence of events.
- A process in its own right as it has inputs, outputs and activities. This is shown in Figure 2-1

- Usually analyse activities such as manufacturing, administration and product development in order to continuously improve the process.
- Requires a management process to plan and control what is happening.

Project as a Process can be viewed as a series of events or activities that are usually connected or related. (Figure 2-1)

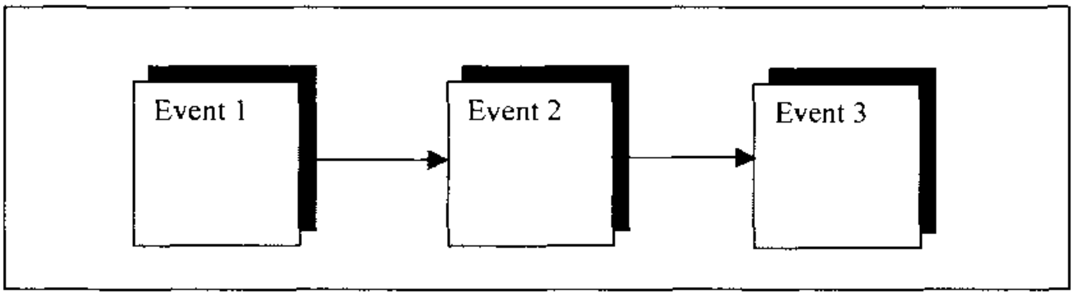

Figure 2-1: Project as a process (Smith, 1997)

However, a project goes beyond just sequencing. It involves converting inputs into an activity to create a desired output. (Figure 2-2)

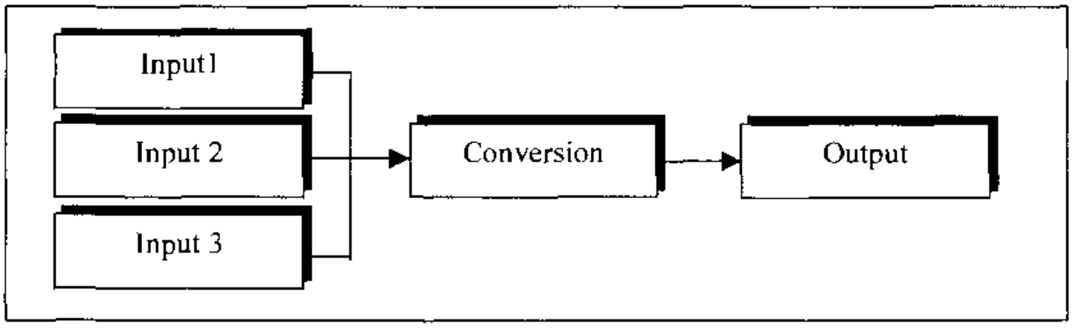

Figure 2-2: Project a user of an analytical process (Smith 1997)

A project normally deals either with problems or performance improvements and should use an analytical process to do so. The improvement process is a combination of techniques for tackling a problem and/or securing an improvement. It is based on the PLAN-DO-CHECK-ACT cycle shown in Figure 2-3. (Smith 1997)

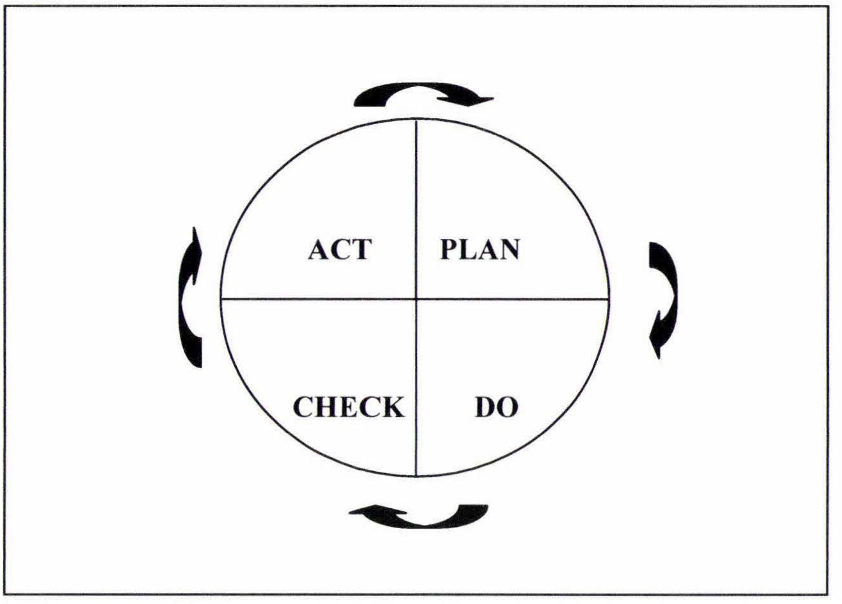

Figure 2-3: PLAN-DO-CHECK-ACT cycle (Smith, 1997)

Smith (1997) further explains how the four stages of the PLAN-DO-CHECK-ACT cycle can be further broken down into 13 more detailed steps. (Figure 2-4)

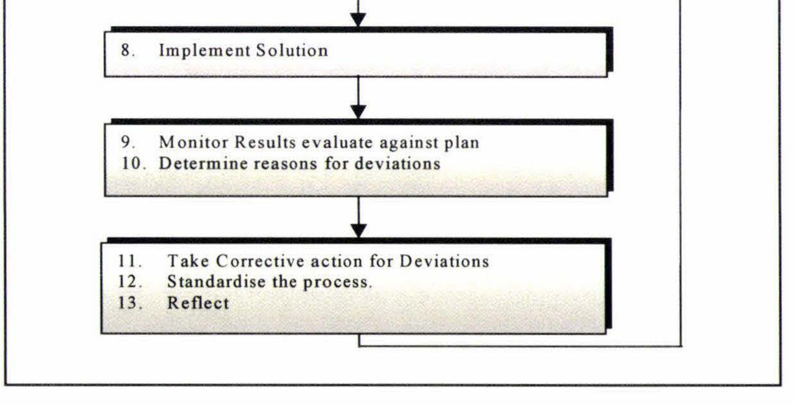

Figure 2-4: A systematic improvement process (Smith, 1997)

Project Management is more than simply managing a project, it demands additional disciplines to those for analysing the problem or process. These additional disciplines included planning and monitoring tools that are essential for effective project management through the five phases in the life of a project shown in Figure 2-5.

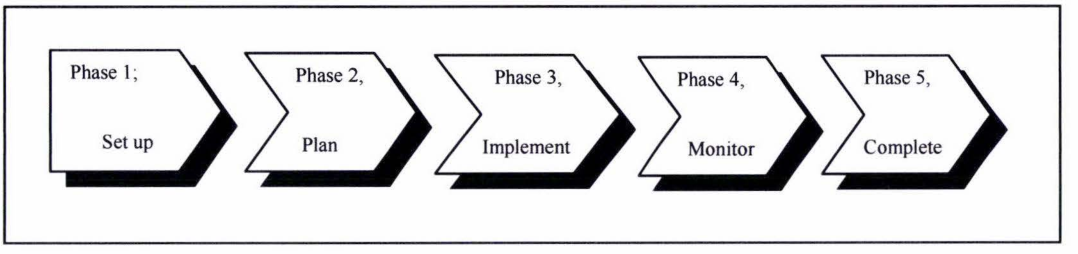

Figure 2-5: Project as a management process (Smith, 1997)

Rosenau, Jr (1998) states that managing projects is a three-dimensional objective, with the simultaneous accomplishment of the performance specification, the time it takes to complete the project and the project budget. This concept is labelled as the triple constraint. The main aspects of the triple constraint definition are as follows:

- The Triple Constraints defines all projects.
- The Triple Constraint consists of performance specifications, a time schedule, and a money or labour hour budget.
- Obstacles that prevent satisfying the Triple Constraint are not mutually exclusive.
- Project specifics determine then relative performance of each dimension of the Triple Constraint.
- Adequate and clear discussions among the project manager, supervisors and technical personnel can help avoid many common problems.

Jessen (1998) asserts that the gap between theoretical project management and practical project management is widening. Having the ability to draw upon previous project experience and project tacit knowledge is the driving force behind the management of projects is used to help solve current problems. (Figure 2-6) This should not, however, prevent each and every project leader from considering the theoretical wisdom that is actually available, and thus taking steps to include the best theories in an effort to improve his or her own leadership and management style and performance.

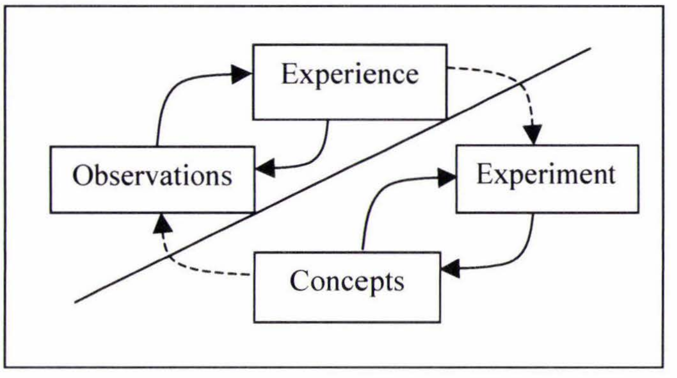

Figure 2-6: The relationship between theorists and practitioners in project work (Rosenau Jr, 1998)

It is also stressed that projects are defined by the following characteristics. Jesson (1998)

- Projects are always problem orientated, i.e. the effort is not haphazard but the result of a qualified desire, and an identified problem or a recognised need.
- It is a goal setting endeavour, i.e. its main objective is clearly identifiable and practically attainable.
- It is resource constrained, i.e. it has to be executed within the defined limits in terms of time, personnel and capital outlay. A further restriction is that the period of time spent on the project must fall within a particular starting and finishing date. The monetary resources requested should cover both direct and indirect expenditures and the human resource component must be defined in terms of the quality and the quantity required to fulfil the chosen objective.
- It is unique
- It is recognisable. In other words, there are no "virtual" projects, only real ones.

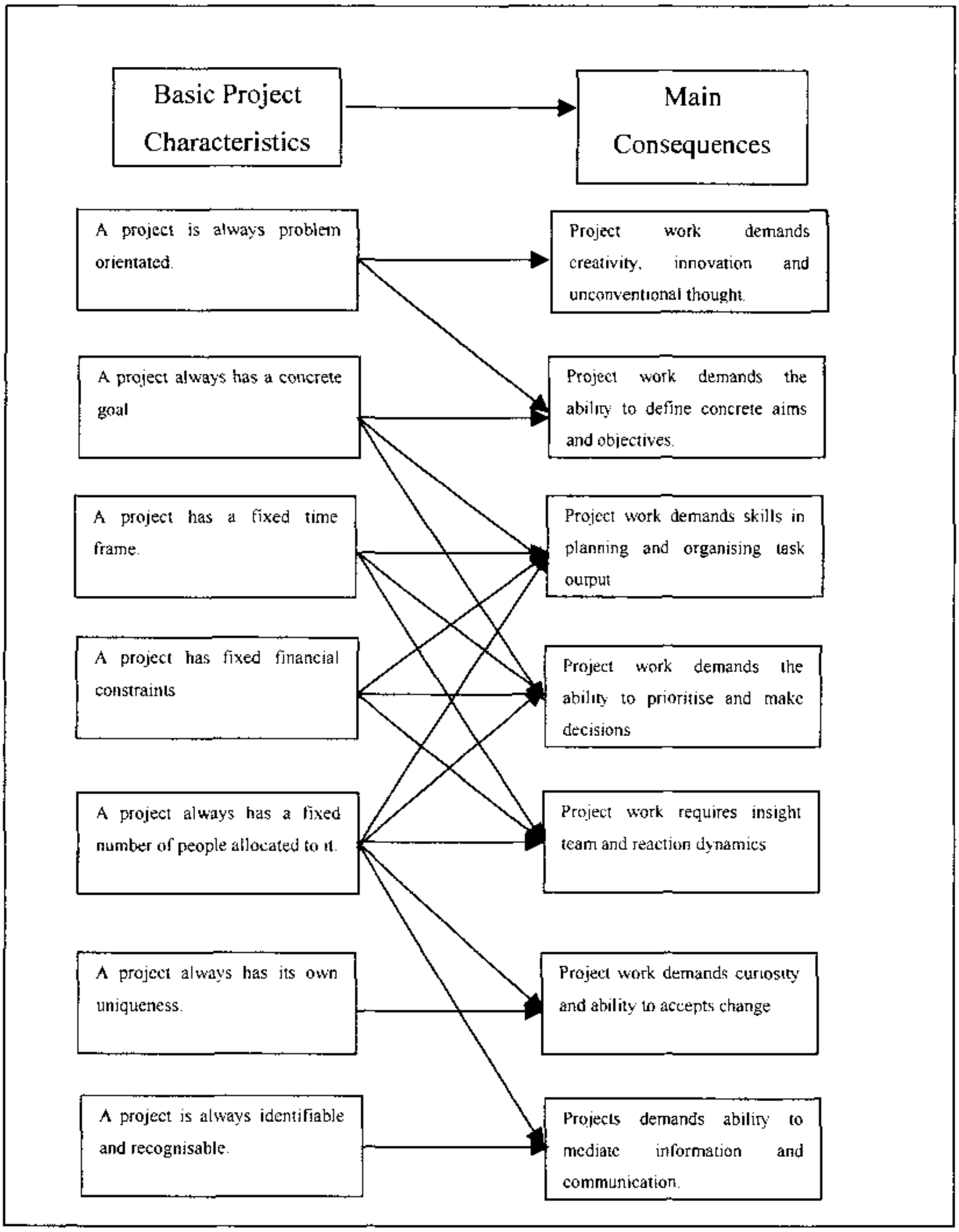

Figure 2-7: Links between the basis project characteristics and consequences (Jessen, 1998)

2.1.2. Planning the Project

2.1.2.1. Project Goals and Aims

Project aims and objectives are the direct outcomes of the following three factors (Smith, 1997)

- Where are we now?
- Where do we want to get?
- Defining which way you will go to get there.

The purpose of a project is to satisfy an aim or an overriding goal. In contracted projects the definition of the goal is easy to define, however the contracted firm or worker usually determines the objectives. Hamilton (1997) has defined a projects gaols and objectives as a pyramid. (Figure 2-8) The top of the pyramid is the defining goal or mission of the project. If the base of the pyramid is not reinforced then the top will collapse, thus it is imperative that the projects primary objectives and the projects enabling objectives are clearly defined and clearly planned. (Hamilton, 1997)

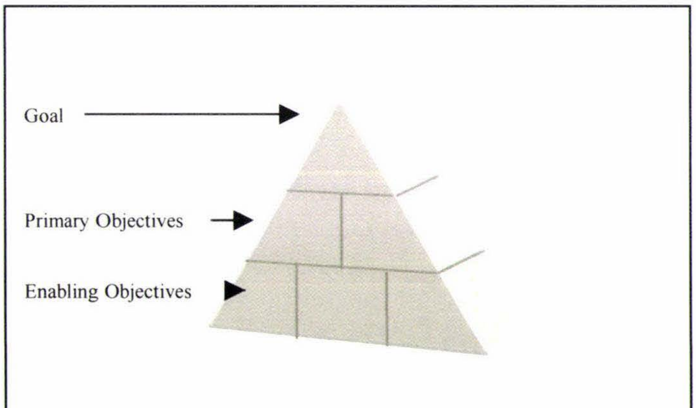

Figure 2-8: Pyramid of Goals and Objectives (Hamilton, 1997)

A project goal statement will clearly describe the direct function of the product or the service that is to be designed for. The aim should outline the characteristics required to lift the product or service beyond today's level and should be exciting yet feasible.(Hamilton, 1997)

The objectives however should be more specific. Primary objectives should be clear, concise and sufficient but few in numbers. Smith (1997) developed an expansion for the acronym SMAARTDUDES that can be used to assist writing concise aims and objectives for a project. (Figure 2-9)

Specific	Clear not vague
Measurable	Change, correction or improvement should be quantifiable
Agreed	Between commissioner and project team
Achievable	Attainable in the short term
Realistic	Achievable within the agreed period.
Time bound	Defined period for achievement.
Demonstrable	Verifiable achievement.
Understandable	Comprehensible to all concerned, in particular commissioner and team should share common understanding
Deliverable	Results capable of being delivered by the team selected
Elevated	Outcome or result should directly contribute to a higher level goal or objective
Singular	One explicit end result or outcome. (More than one implies there should be more than one objective)

Figure 2-9: SMAART DUDES expansion for objectives (Smith, 1997)

2.1.2.2. Task Breakdown of Project

In order to achieve these objectives, in order to achieve the ultimate aim or goal a plan needs to be designed and implemented.

Rosenau Jr (1997) developed the Work Structure Breakdown (WSB) as a method to divide projects methodology into smaller more convenient work packages. WSB is simply a flow chart that illustrates and defines small work packages, the time schedule that is attached to them and the resources that will be used to complete them. However task size is very important. There are 7 factors that have the ability to affect task size. (Table 2-1)

Factor	When to Use Smaller Tasks	When to Use Larger Tasks
Management Effort	You can afford to spend more money on time and resources	You want to spend less time creating the WSB
Number of Tasks	You want more detail	You want less detail
Spending Authorisation	You want to limit the amount of financial or resource commitment during a specific time interval	Task managers have previously demonstrated prudent use of money and resources
Task Duration	You want to encourage faster completion of tasks.	You can wait longer to see tasks completed.
Monitoring Accuracy	You desire a greater level of accuracy.	You can tolerate less accuracy.
Company's prior experience with similar work.	Your company has little or no previous experience.	Your company has expertise in specific work of the task.
Task Manager's Skills	You are using an inexperienced person.	You are using an experienced person.

Table 2-1: Factors that affect task size. (Rosenau Jr, 1998)

Figure 2-10 is a WSB for the design and assembly of a Photovoltaic Solar Cell. This particular WSB has been written to 2 levels of detail. The first identifies the main areas of the design and the second level describes the design aspects of each area pointed out in the first level. There is no magic formula for completing a WSB for any given project. The greater numbers of levels the smaller the tasks are more financially straining the project becomes.

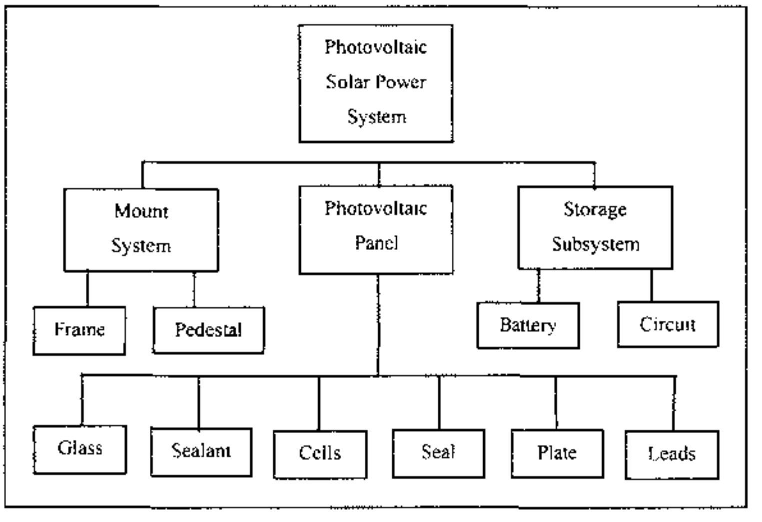

Figure 2-10: Work Structure Breakdown (Smith, 1997)

In general, it is best to structure the WSB on tangible, deliverable items, both software and hardware.

Similar to the WSB, the use of conversion diagrams takes the first level of the task breakdown and produces a series of inputs, throughputs and desired outputs. (Smith, 1997) Projects are seen as conversion processes. (Figure 2-11)

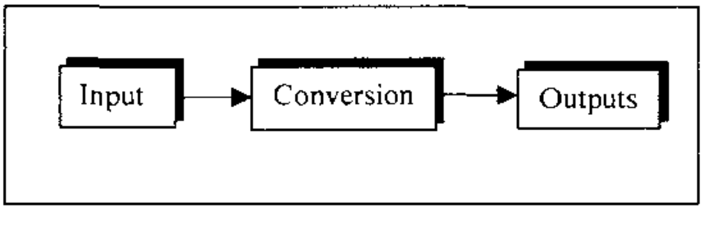

Figure 2-11: Conversion Process of a project (Smith, 1997)

Smith (1997) asserts that the following steps should used in developing a the conversion diagram shown above:

- Reflect on the brief. In light the main goal and the primary objectives, what outputs will you have to produce? From this point produce a required output chart. (Figure 2-12)

Required Outputs (Results, reports)	When

Figure 2-12: Required Outputs Table (Smith, 1997)

- How will you know if you are achieving these outputs? What measures do you need to put in place to tell you? Who will do the recording/reporting.
- From a project management point of view, how will you what is progress is being made in terms of meeting the output requirements or using resources?
- Reflect on the realism of the outputs and the timings you have identified. Are they achievable? Are they too easy?
- If you are satisfied add them to your brief.

The actual conversion of the inputs requires several different components. It requires a mechanism to drive it and knowledge of all the constraints that will hinder its performance. Figure 2-13 is a diagrammatic view of the conversion process.

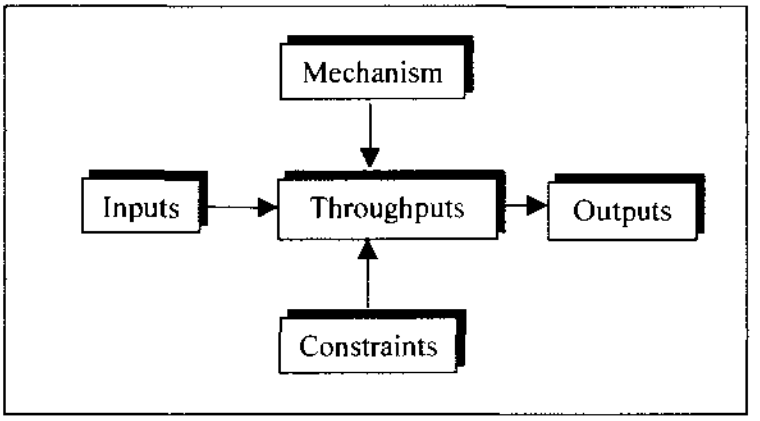

Figure 2-13: Throughput Conversion Diagram (Smith, 1997)

This provides project managers with a far greater detailed breakdown of the tasks. The completion of this chart for each of the required tasks within a specific project will give project operators enough detail to schedule the project, outline resources to be used and enter in any buffers to compensate for predicted delays. (Smith, 1997)

2.1.3. Scheduling and Time Management

Hamilton (1997) states that no project should be undertaken without a schedule. A project schedule brings together:

- The key activities and tasks
- How long each activity and task will take
- Responsibilities
- Resources required.

Hamilton (1997) also states that the main purpose of a schedule is to obtain a clear picture of:

- The order of tasks
- When tasks will be done

- Inter-dependencies between tasks and activities
- The total elapsed time, taking into account the availability of appropriate resources.

Once the schedule is completed it can be used for ongoing monitoring and overall control of the project. There are three ways to produce a schedule for a project. These are:

- The Gantt Chart or Bar Chart
- Critical Path Method (CPM)
- Programme or Performance Evaluation and Review Technique (PERT)

For the majority of short and simple projects a Gantt Chart can be implemented. However larger, more complex and resource consuming projects, the Gantt is inadequate and the CPM and the PERT are more appropriate. The reason for this is that the Gantt is unable to show the inter-dependencies and relationships between the activities and the tasks. Thus the schedules produced can be misleading.

CPM scheduling is used where there is familiarity with the tasks involved, because they have been done many times before. Time estimates are thus based on historical data. A PERT chart employs statistical probability analysis in circumstances in which a project is likely to involve activities or tasks for which no previous record or experience exists.

A Gantt Chart is a simple charting technique to illustrate actions against time, and dependencies between different actions (Figure 2-14). It is similar to the Critical Path Analysis. Once you have determined the tasks to be completed for the project then the next step is to look for sequences and dependencies. The next stage is to size them in terms of time it will take to complete the task. Finally display these onto a Gantt Chart, spread between the start and end dates of the project. (Shekar, 1997)

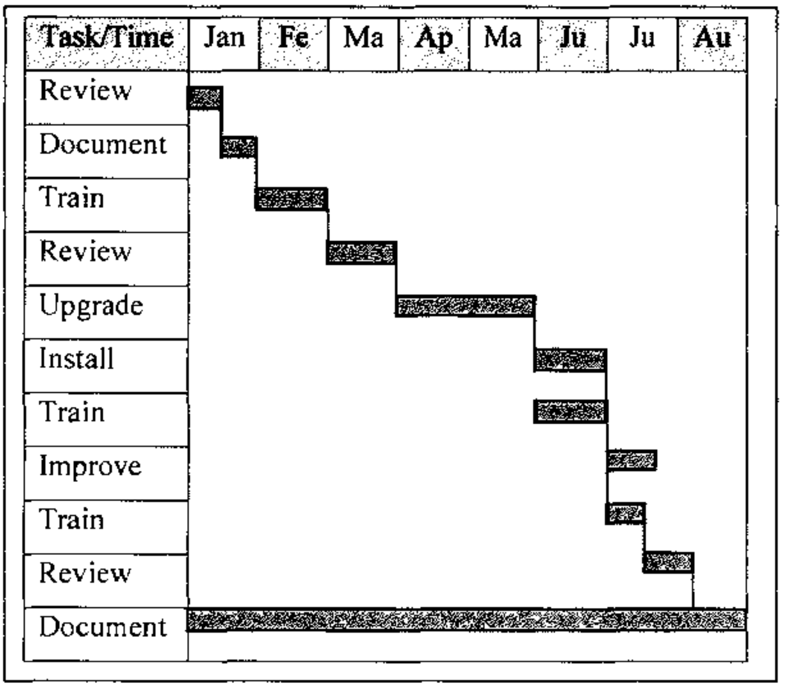

Figure 2-14: Example of a simple Gantt Chart .

The more complex method of Critical Path Analysis is a way of ordering tasks to dependencies and the time taken. It is therefore useful as a planning technique as well as a monitoring technique, particularly on more complex projects. Critical Path charts are also referred to as Arrow Diagrams or Process Decision Programme Charts. They are similar in many ways to the Gantt Chart. CPM analysis shows in a network diagram (Figure 2-15):

- The critical tasks in terms of impact on the project time
- The most effective way to schedule tasks to achieve the earliest possible target date.

The methodology used for the CPM is as follows:

- Outline the tasks involved in completing the project.
- Identify the length of time it will take to complete each of these tasks.

- Arrange these tasks into the order that they are to be completed in. Look for all possible dependencies and also the possibility of parallel tasking. At this stage it also possible to remove any unnecessary tasks and add any which may have been missed previously.
- Link these tasks showing all dependencies.
- Number these tasks to show the exact order they are to be completed in.
- The critical path is the shortest line of the arrows through the diagram. (In terms of elapsed time) This will show the absolute minimum time that the project will be completed in.
- Tasks on the critical path should be started as early as possible, taking into account dependencies and outside constraints.
- Regularly review progress against the chart and amend as appropriate, particularly if there has been slippage on the critical path.

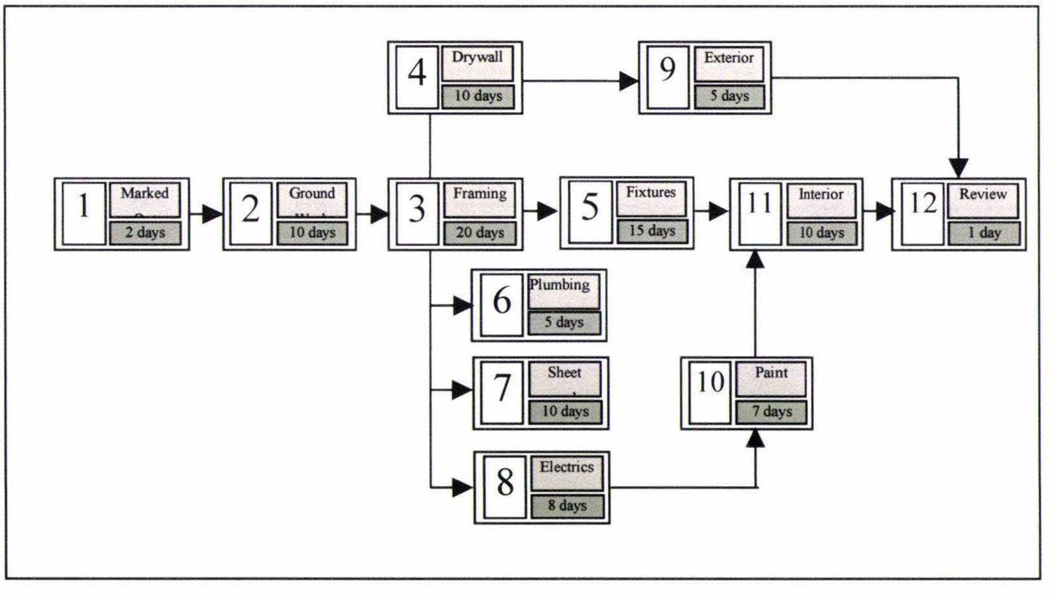

Figure 2-15: Process Decision Programme Chart (Smith, 1997)

CPA is a useful tool for determining the shortest time for achieving a particular task or project and the sequence of events and timing that must take place to achieve this. If a project falls behind the critical path, the technique can be re used to re estimate the finish time. A CPA also highlights any slack time around tasks not on the critical path that gives flexibility on when they can be completed.

A differing interpretation of CPA is that once the tasks are broken down you must then allot both an earliest possible finishing time and the latest possible finishing time. The following network diagram shows a list of three events and the estimated times to complete them.

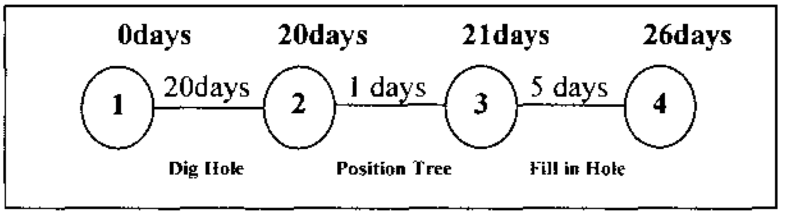

Figure 2-16: Tree Project Network Diagram (Smith, 1997)

From Figure 2-16 above it can be said that the project is going to be completed in 26 days. Notice, however that the estimated duration is written above each activity arrow, with concise activity description below. Adding up the activity duration from left to right along the arrow path derives the estimated achievement time for each event. These estimated times for events are obviously the earliest possible times hy which they can be achieved.

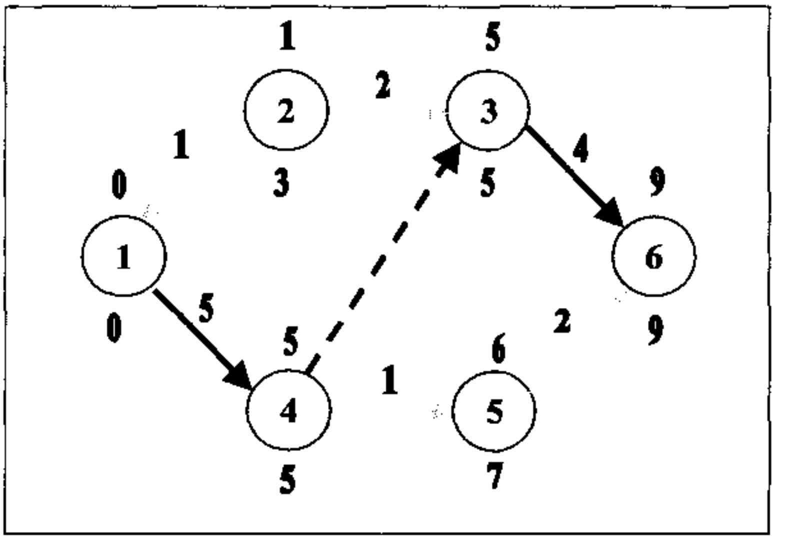

Figure 2-17: An example of an arrow network time analysis (Smith, 1997)

The dotted line in Figure 2-17 above shows the inclusion of a dummy activity. This is not a real activity and usually is allocated a zero time frame, but it acts as a constraint on its following ties. Thus in this example, activities 3 to 6 cannot start until activities 2 to 3 and 1 to 4 have both been finished. The times above the event circles show the earliest possible event times calculated by adding all the duration estimates from left to right, as already shown on the Figure 2-16. In this example, the path through the dummy has determined the earliest possible time for event three. The numbers below the circles have been found by subtracting the estimated activity duration's from the earliest time of the last event, working this time through all paths from right to left. These numbers represent the latest time by which each event must be achieved if the end of the project is not to be delayed. There will always be at least one path where the earliest and the latest times are the same. This path is known as the Critical Path and is indicated by the darker arrows in Figure 2-17. (Smith, 1997)

With the modern facilities available to us this sort of path and network analysis can be completed using a computer programme. Microsoft project is a readily available programme that allows the user to list the tasks and the duration for which they are to be completed in. The programme then has a series of tools and functions that will measure and illustrate the project management tools outlines previously. (Microsoft, Microsoft Project Help, 1997)

2.1.4. Execution of Project

Successful Project Management is often complex and difficult. Smith (1997) suggests that project managers must attend to a variety of human, financial and technical factors. In reality, implementation is inseparable from monitoring and control as the 'doing' and 'checking' happen along side each other. Basically implementation is about getting the job done according to plan and ensuring that a number of things are in place to support this activity and manage the consequent changes.

The following list, is a set of tools that could be used as a means of executing a project plan.

- Review the checklist outlined in Figure 2-18.
- Identify which elements you feel are in place and working successful.
- Identify those elements you need to work on to improve the way implementation is going.
- Refer to other more specific tools as appropriate to work out what to do.

✓ ***An effective communications system:*** Knowing what should be communicated, to whom, by whom, when, what outcomes are required, etc.

✓ ***Effective teamwork:*** Work training, support, review mechanisms are in place. Is the responsibility chart working?

✓ ***Information Systems***: Have measures been agreed? How will data be captured, who will do it? How will it be done? How will it link into the communications system?

✓ ***Contingency Planning:*** Has this been done thoroughly enough? How are you dealing with unforeseen problems.

✓ ***Progress monitoring and review:*** Is the planned frequency and format working.

✓ ***Customer Focus:*** Is the focus on customer and/or end users views and

Figure 2-18: Effective Implementation needs checklist (Smith, 1997)

2.1.5. Monitor and Progress Reporting

Progress monitoring reporting is essential to ensure project control. Monitoring should tell you the following: (Rosenau Jr, 1998)

- Is the work been done within the estimates?
- Will each activity be completed on schedule?
- Is the quality of work within specification.
- Are the expected results being achieved?
- Are there other changes or special problems?

Knowing these on a regular basis allows you to take timely corrective action which may involve (in the order of decreasing acceptability)(Rosenau Jr, 1998)

- Rearranging workload.
- ~~Putting in more resource or effort.~~
- Moving the target completion date(s).
- Lowering the targets of the project.

In its most basic form project control systems can be viewed as a simple systematic process:

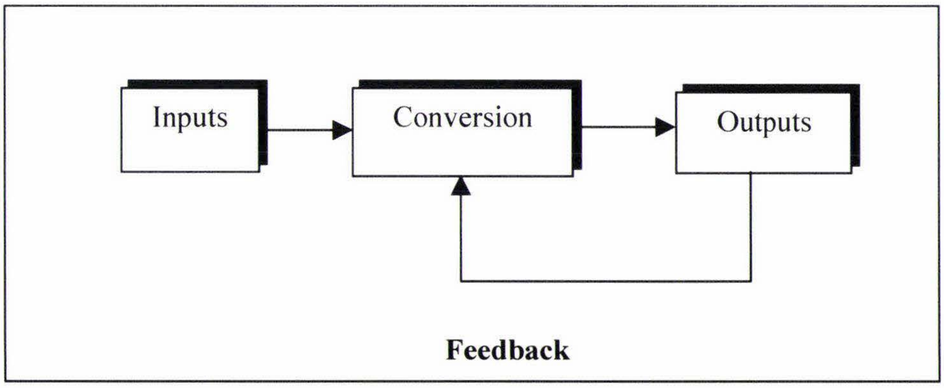

Figure 2-19: Feedback Loop Process (Smith, 1997)

The process should follow a number of principles. This checklist compares current approach with these principles: (Smith, 1997)

- Identify the information you need to track your project in terms of:
    - Progress towards the objectives
    - Completion of specific tasks/key activities.
    - Efficient use of resources.
    - Adherence to time schedules.
    - Effective team schedules.
- Decide how to get this data and use it on a regular basis.
- Design a process for achieving this using the checklist in Figure 2-20:

✓ Control work....not workers
✓ Base Control on work completed
✓ Base control of complex work on motivation and self-control.
✓ Build in means of gathering control data into the project work process.
✓ Ensure control data goes to the person who does the work.
✓ Design the control system for the routine.
✓ Define the criteria for control in the early stages of the project

Figure 2-20: Checklist for Control of Process (Smith, 1997)

- Check that your proposed control system also meets the four basic requirements in that it will allow you to:
    - Plan Performance.
    - Observe actual performance.
    - Compare plans.
    - Adjust as required.
- Finally, ensure that your system is:
    - Focused on priorities.
    - Responsive, i.e. initiates corrective action.
    - Timely – no unnecessary delays.
    - User Friendly.

- Flexible.
- Simple and clear.

(Smith, 1997)

2.1.6. Completing and Reviewing the Project

The first and most important aspect of completing a project is to prepare and review a pre-completion review. A pre-completion review is primarily for the benefit of the principal customer, the project leader or the client that has contracted the work. Its purpose is to enable the commissioner to decide:

- If the team has fulfilled its contract, and hence
- Whether or not the contract should be brought to a close.

When a project has been proceeding according to a plan, the agenda for the pre completion review should be straightforward. It is used to:

- Review with the client the results that have been achieved in relation to the objectives agreed in the contract
- Agree on any issues relating to hand over and standardisation of changes
- Review the effectiveness and the efficiency of the main processes in the life of the project
- Discuss arrangements for completion and wind-up of the project.

The review should be held as close as possible to the planned termination date for the project, but allowing time for any loose ends to be sorted out before the team disbands. (Hamilton, 1997)

Smith (1997) suggests the use of the following steps to complete an end of project review.

- **Copy of the original contract and any subsequent amendments.**
  This is important because any disputes about the outcome of the project will be more or less resolved if there is a common understanding of the starting point, the general aim or mission statement.

- **Assessment of results in relation to objectives.**
  There are three elements:
  - Has the required outcome or performance met the primary objectives?
  - Has this been achieved on budget?
  - Has this been achieved on schedule?

- **Deviation Analysis.**
  Reasons for significant under or over achievement should be identified.

- **Corrective Actions.**
  Where the team or workers has had to take action to bring the project back on schedule, or performance back into line with what was planned, this should be fully explained as should any cost implications.

- **Current Performance or Status.**
  The content will be dictated largely by the timing of the review, for instance, in relation to hand-over to others for day to day management of whatever the project team has been responsible for producing.

- **Ongoing Progress Monitoring**
  Especially in the case of projects whose output is concerned with the process improvement, it is extremely important that the project team should have given thought to:
  - How performance of the new/improved processes can be monitored on a day to day basis.

- How benefits and savings can be traced and tracked once it has completed its task and been disbanded.

Amongst other users, this will help any subsequent assessment of the benefits of an improvement programme.

- **Potential problem or risk assessment**

Where this is permanent, then the project manager should be left in no doubt about what might place the project teams contribution or output at risk.

- **Handover arrangements**

Where relevant, these should be described. A project leader will need to be assured that once the project team has stood down, the new process, facility or whatever, will be properly managed.

2.2. Retail Packaging Materials

2.2.1. Paper Based Packaging

2.2.1.1. Definition

Paper is defined as a matted or felted sheet usually composed of plant type fibre. Paper and paperboard are non-specific terms that can be related to either material calliper (thickness) or grammage (weight). The grammage of boards is measured by the mass of the paperboard in one square metre. The thickness of paperboards is measured in micrometers (μm). (Soroka, 1995)

2.2.1.2. Applications

Paperboard provides a versatile and economical material not readily matched by other packaging mediums. Effective paperboard package design is based partly on knowledge of paper and product properties and partly on craftsmanship and art. Paperboard packaging can be considered in a number of categories.

Paperboard can be considered in each of the following forms of packaging:

- Folding Cartons: Folding cartons are the most common source of paperboard packaging. These are generally pre-glued and assemble for shipping. They are then reduced and flattened for further use.
- Beverage baskets: Variation to the folding carton typically designed to hold 4 or 6 bottles. Because of their weight the package is usually constructed from kraftpaper.
- Set up Cartons: Pre erected cartons. Usually used for cosmetics, novelty gifts and some liquid products.
- Carded Display Packaging: Simply a plastic package with a die cut card display within the product.
- Gable top containers: This is the main application for milk and fruit juices. These boards are usually polyethylene coated to improve barrier qualities and are pre erected for filling.

- Spiral and Convolute Cans: Spiral wound cans are usually made from two or three overlapping winds of kraft paper. This form of packaging has typical applications like Pringles Chips and the game Pick up Sticks.
- Corrugated paperboards (Soroka, 1995)

2.2.1.3. Relevant Data

2.2.1.3.1. Solid Fibre Board

Solid fibreboard is a single thickness board that is manufactured for the smaller Fast Moving Consumer Goods. A common example of solid fibreboard is the "Sanitarium Weet-Bix" package. Solid fibreboard is used primarily for protection and display.

The following tables show the related data of thickness and grammage of the retail type solid fibreboard.

Formakote White:

Thickness (μm)	300	350	400	450	500	550	650	700
Tolerance (μm)	+/-25	+/-25	+/-25	+/-25	+/-5%	+/-5%	+/-5%	+/-5%
Grammage (gm^{-2})	220	246	276	305	332	357	410	437
Tolerance	+/-5%	+/-5%	+/-5%	+/-5%	+/-5%	+/-5%	+/-5%	+/-5%

Table 2-2: Formakote White Thickness and Grammage Data (Meltza, 2000)

2.2.1.3.2. **Formakote Manillaback:**

Thickness (μm)	350	400	450	500	550	650	700
Tolerance (μm)	+/-25	+/-25	+/-25	+/- 5%	+/- 5%	+/- 5%	+/- 5%
Grammage (gm^{-2})	238	264	290	316	342	395	422
Tolerance (gm^{-2})	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%

Table 2-3: Formakote Manillaback Thickness and Gram Data (Meltza, 2000)

2.2.1.3.3. **Formakote Packaging Board:**

Thickness (μm)	300	350	450	500	550	630	675
Tolerance (μm)	+/- u25	+/- u25	+/- u25	+/- 5%	+/- 5%	+/- 5%	+/- 5%
Grammage (gm^{-2})	240	275	326	358	389	439	469
Tolerance (gm^{-2})	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%

Table 2-4: Packaging Board Thickness and Gram Data (Meltza, 2000)

2.2.1.3.4. **Formakote Carrier Board:**

Thickness (μm)	350	400	450	500	550	600	630	650	700
Tolerance (μm)	+/-25	+/-25	+/-25	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%
Grammage (gm^{-2})	282	319	355	390	425	462	485	500	538
Tolerance (gm^{-2})	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%	+/- 5%

Table 2-5: Formakote Carrier Board Thickness and Gram Data (Meltza, 2000)

2.2.1.3.5. Corrugated Fibre Boards

Corrugating board is the largest single grade of paper produced, from the standpoint of the paper and paperboard industry. This grade is also one of the largest forms of packaging due to the universal use of corrugated containers for shipping manufactured goods. Corrugated Board is characterised by its cellular structure that imparts high compressive strength at relatively low weight.

The corrugating operation uses two types of product from the paper industry. Corrugating medium also known as fluting in the centre piece of the board. An outer and an inner linerboard surround the medium or fluting. Figure 2-21 shows the manner in which the three layers are put together. (Robertson, 1997)

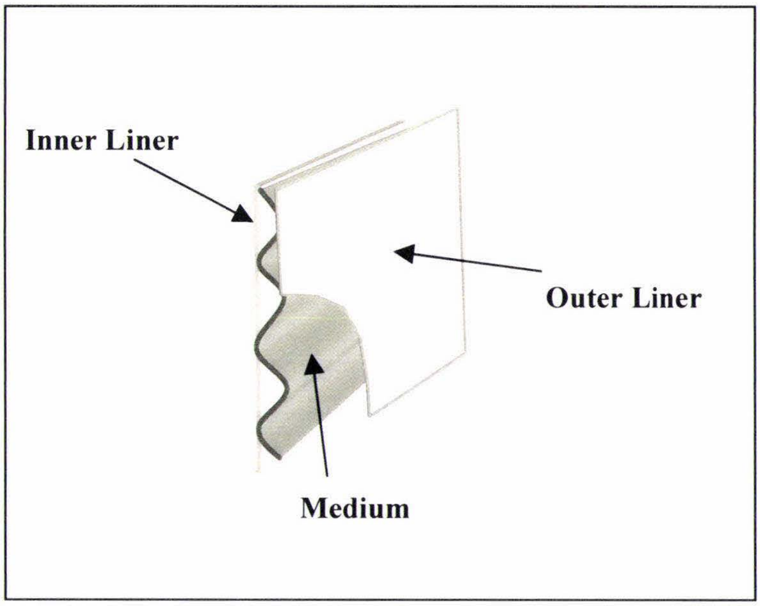

Figure 2-21: Schematic of Corrugations (Robertson, 1997)

The liner and the medium may be arranged in a number of different ways to produce a range of corrugated fibreboards. The simplest of the corrugated boards is the single faced board that consists of one liner and only one medium. The corrugated boards also offer double wallboard and triple wallboard. Each board is labelled depending on its paper grade make up. For example, a board labelled 616 would indicate that it's inner and out layers are grade six and the medium layer is a grade 1 linerboard.

Table 2-6 shows the most commonly used paper grades used in New Zealand.

Grade	Grammage (gm^{-2})
1	120
2	160
3	220
6	290

Table 2-6: Table of Paper Grades for Corrugated Boards

(Amcor Packaging, 1997)

The type of fluting or corrugations, in particular flute height and the number of flutes per unit length can further define corrugated boards. These two properties determine the theoretical take up factor of the boards.

Theoretical take up factor = A

Length of fluting medium before corrugation = B

Liner Length Ratio = C

Where A = B / C

Equation 2-1: Theoretical Take Up Factor Equation (Robertson, 1997)

The corrugations are divided into one of the following four sizes A, B, C or E. Table 2-7 explains the flutes and their specifications. This includes the heights of the flutes and the number of flutes per metre in the board.

Types of Flute	Heights of Flute (cm)	Number of Flutes (per m)
A	0.470	110
B	0.361	128
C	0.246	154
E	0.114	315

Table 2-7: Table of Flutes Specifications (Robertson, 1997)

Each of these flutes has a varying array of properties. Flute A is a maximum cushioning board. This board is usually used for cushioning fragile products, quite often audio equipment is packaged with flute A boards. Flute B is an easy to print on board that has a high resistance to flat crush[1]. The most common used flute is flute C. This board gives the user a compromise between the properties offered by both flutes A and B. Flutes E and F are micro flutes boards and they are the competition for solid fibreboard packages. Flutes E and F's properties are equal to that the solid fibreboard offers but it also offers extra cushioning with the micro corrugation. Flute E and F are therefore lightweight, offer insulation protection but also offer cushioning.

The take up factor of the fluting is the length of the fluting before the corrugation to liner length ratio.

Table 2-8 shows the average take up factors for the different flutes.

Flute	Take Up Factor
A	1.54mm
C	1.45mm
B	1.33mm
E	1.26mm

Table 2-8: Theoretical take up factors for Corrugated Boards (Robertson, 1997)

This is important for calculations of the quantity or area of medium in a particular board. For example an 626 C flute board with both it's inner and outer layers cut to size of 100cm^2 would mean that the medium is 14.5cm x 10cm. Therefore, if the weight of the board would be 75.2 grams. (Robertson, 1997)

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[1] Flat crush: is the measure of resistance of the corrugated board to a crushing force applied perpendicular to the surface. This test provides some indication of the durability of the finished corrugated container.

2.2.2. Plastic Packaging

2.2.2.1. Definition

Plastic describes the ability of something to be moulded or formed. In the past this term has been referred to clay, wax and other malleable products. With the advances in chemical research, the term plastic has been described as a modified natural resin and then a large group of synthetic materials that can be formed into shapes. Today these plastics are described as polymers. Polymers are formed when a large number of identical repeating units are joined together to make a very large molecule, "Poly" meaning parts and "mer" meaning the small repetitive unit in the polymer and for this example it is based around a carbon atom.

Polymers can be grouped into two distinctive classes, thermoplastic and thermoset. These classes are categorised by their behaviour under heat. Only a few of the polymers available are useable in a packaging application. These polymers are all a part of the thermoplastic family. (Soroka, 1995)

2.2.2.2. Polyethylene (PE)

The are three common types of Polyethylene used for packaging applications. They are High Density Polyethylene, Low Density Polyethylene and Linear Low Density Polyethylene.

2.2.2.3. High Density Polyethylene (HDPE)

Most consumer and industrial blow-moulded containers are HDPE. Table 2-9 outlines the proportions of some of the applications of HDPE. HDPE has very good moisture barrier qualities; hence it is used for bags and food packages to maintain freshness and quality within the product. Other recognised packaging applications of HDPE are fertilisers, agricultural goods, swimming pool cleaners and chlorides, institutional foods and some paints.

HDPE Markets	Millions of Kilograms
Bottles	1144
Bags and sacks	425
Food Packaging	73
Bottle Closures	56

Table 2-9: Major American packaging markets for HDPE. (Soroka, 1995)

2.2.2.4. Low Density Polyethylene (LDPE), Linear Low Density Polyethylene (LLDPE) and Ethylene-vinyl Acetate (EVA).

EVA is regarded as a copolymer of Polyethylene. Its properties and applications are similar to those that are held by LDPE. The market for LDPE and EVA film alone, far exceeds that for all other forms of plastic. A more detailed review of proportional film usage in America is provided in Table 2-10.

Film Markets	Millions of Kilograms
Trash Bags	678
Food Packaging	531
Retail Bags	455
Stretch Film	291
Industrial Liners	94
Shrink Film	89
Heavy Duty Bags	72
Multiwall Bag Liners	26
Misc Applications	261

Table 2-10: Major North American packaging markets for LDPE, LLDPE, EVA films. (Soroka, 1995)

2.2.2.5. Polystyrene (PS) and Expanded Polystyrene (EPS)

Applications of Expanded PS are loose filled cushioning, hot beverage cups and takeaway food containers. Non expanded PS packaging applications include, single serve portion cups, windowed containers, bottle labels, candy trays and breathable wrap for fresh produce and yoghurt pottles. Table 2-11 outlines the common retail uses and the volume consumed in the American market.

PS Markets	Millions of Kilograms
Closures	47
Rigid Boxes	43
Food Containers	145
Loose Fill	37

Table 2-11: Major North American packaging markets for PS. (Soroka, 1995)

2.2.2.6. Polypropylene (PP)

Common packaging applications of PP include heat sealable packages, snack food wraps and overwraps for cigarettes and confectionery. Potato Chips packets, cookie and biscuit packages and chocolate bar wrappers are also common applications of PP but in combination with layers of itself and extruded metal films. PP common packaging applications and their use are detailed in Table 2-12.

PP Markets	Millions of Kilograms
Film Wrap	265
Consumer Containers	41
Medical Containers	25
Packaging Closures	240

Table 2-12: Major American PP packaging markets. (Soroka, 1995)

2.2.2.7. Polyethylene Terephthalate (PET)

PET can either be extruded to form films, injection or blow moulded into bottles or other packaging applications. Common application of PET in the retail sector are bottles, sandwich packs and biscuit trays. Table 2-13 gives an indication of the proportion of use within the American market.

PET Markets	Millions of Kilograms
Soft Drink Bottles	461
Other Bottles	254
Trays and Parts	50
Ovenable Trays	26

Table 2-13: Major American PET packaging markets. (Soroka, 1995)

2.2.2.8. Polyvinyl Chloride (PVC)

Plasticised PVC has properties that allow it to be used for cling films and as wrap for freshly packed meats. But it can be found more prominently as wraps for toys, boardgames, audio and videotapes. Another common use of PVC is for storage of pharmaceutical goods. Table 2-14 shows the three main uses of PVC in the retail industry. However, in recent times PET has almost completely cannibalised the PVC clear bottle market. (Soroka, 1995)

PVC Markets	Millions of Kilograms
Film Wrap	89
Moulded Bottles	82
Pharmaceutical	37

Table 2-14: Major American PVC packaging markets. (Soroka, 1995)

2.2.2.9. Total Plastic Packaging Market

The majority of plastic packaging in today's retail sector is made up of the plastics discussed previously. Table 2-15 clearly shows the plastic and the proportional use of all the plastics and the fields of the retail packaging sector that they are a part of.

Material	Millions of Kilograms	Common Applications
HDPE blown	1115	Food, household chemicals, toiletries
PET, injection	716	Carbonated Drinks, medicine bottles
HDPE, injection	550	Crates, pails, dairy tubs, cans
PS, thermoformed	237	Disposable dishware, trays
HIPS, high impact PS	205	Disposable dishware, trays
HDPE, blown	154	Pails, drums
PP, injected	122	Dairy tubs
LDPE, injected	118	Pails, tubs
PVC, blown	81	Clear bottles
PS, injection	78	Decorative boxes, produce baskets, cups
PET, thermoformed	76	Oven dishware, containers
PP, blown	66	Medical containers
PS, foam	49	Disposable dishware
LDPE, blown	49	Squeeze bottles
PP, thermoformed	29	Portion Cups
PP, extruded	25	Straws
PVC, thermoformed	20	Blister packs
PS, thermoformed sheet	16	Portion cups
Polycarbonate	10	Milk Bottles, returnable water bottles
Styrene-acrylonitrile	6	Chemical containers
PS, blown	4	Cosmetic containers

Table 2-15: Complete plastic applications by container type. (Soroka, 1995)

☐ Retail Packages	☐ Non Retail Packages

2.2.3. Cans

2.2.3.1. Three Piece Cans (Tin Cans)

Steel is one of the older packaging materials and was originally used all shapes of packaging. Tea and tobacco were two of the first products packaged in tin-plated, mechanically seamed and soldered steel containers with friction or hinged lids.

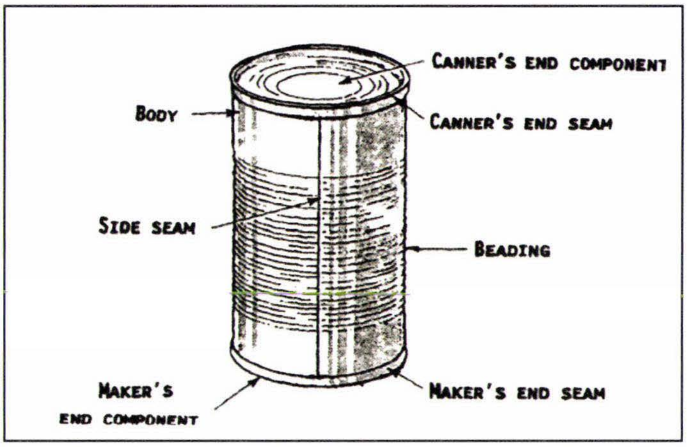


Figure 2-22: 3 piece can (Soroka, 1995)

Common examples are preserved products like fruit, vegetables, fish and prepared meals. Three piece can weight vary depending on which company manufactures them and what type of tin plate is used. Figure 2-23 gives an indication of the labelled product weight versus the estimated package weight of Heinz-Watties cans produced in Hawkes Bay New Zealand.

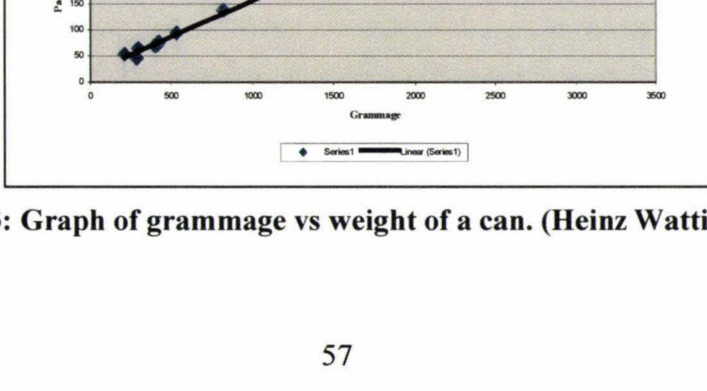


Figure 2-23: Graph of grammage vs weight of a can. (Heinz Watties, 2000)

2.2.3.2. Two Piece Cans

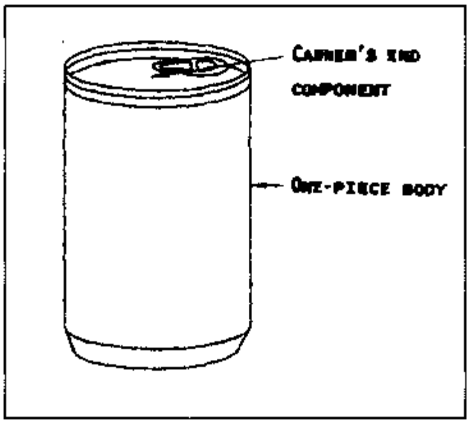


Figure 2-24: 2 piece aluminium can. (Soroka, 1995)

The following list indicates the advantages of the 2-piece aluminium cans for the respective users:

- Decorates to a high standard
- Colour printing (Max. 8 colours)
- Unbreakable
- Light and compact
- Superior flavour protection
- Longer shelf life
- Non-rust
- Reduces transport & distribution costs
- Market return product is minimum
- Marketable in all channels

There are also added advantages for retailers as the 2-piece aluminium can reduces handling and warehousing cost through its lightweight and safety against breakage. It stacks well and chills quickly for shelf serve units. The Aluminium can has the following benefits for the consumer:

- Trendy & classy look
- Light weight
- Convenient
- Easy to open
- Chills easily
- Safe to carry - will not break
- No wastage of drink
- Used Aluminium can is fully recyclable.

(Soroka, 1995)

2.2.3.3. Aerosols

Aerosol packaging refers to products that are pressurised in a container having a valve that permits controlled release of the product, as the user requires it. Personal care products like perfumes, shaving creams, deodorants, hair sprays take up the majority of this market. This market is followed closely by home car products like carpet sprays, fly sprays and cleansers. Hardware applications are also used but are not as common as the two markets previously shown. (Soroka, 1995)

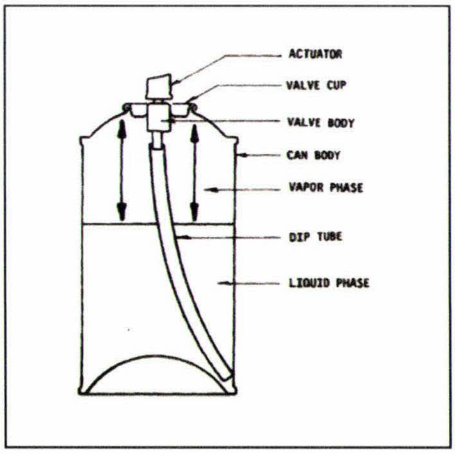


Figure 2-25: Aerosol can section view. (Soroka, 1995)

Different products require different needs from the aerosol package. There are three common materials used to manufacture aerosols. These are tinplate, aluminium and sometimes polymers. There is however a huge variety of nozzle types. These are more often than not manufactured from polymers but the actually function of the nozzle varies. Sizes of the actual aerosol can vary from 100 grams to 500 grams or 50 ml through to 1000 ml depending on the product.

2.2.4. Metal Based Laminated Packages

Rolled aluminium that is less than 152 micrometers is regarded as foil. Aluminium foils have a high resistance to most fats, petroleum-based greases and organic solvents. Generally, food products such as candies, milk, unsalted meats and butter can be packaged with an aluminium package. Generally aluminium packaging is not found primarily by itself, often it is combined with a plastic, paper or paperboard to form a new package. The selection of material depends on the required properties of the product.

The principal reasons for coating aluminium with another material are:

- To render the foil surface heat sealable
- To increase corrosion resistance
- To increase tensile and burst strength
- To produce a specific surface
- To improve adhesion with printing inks
- To enhance the water vapour/gas barrier properties
- To impart high gloss and three-dimensional depth to the product.

The majority of the products packaged with aluminium foils are hard to distinguish. The reason for this is because the foil may me embedded into the structure of the laminate. The proportional make up of the layers in the laminated packages varies from product to product. Table 2-16 gives an indication of the proportion in the laminated products that use aluminium

Product	Type of Laminate
Coffee	0.48 mm metalised BON/2 mm LDPE
Snacks	0.75 mm OPP/0.8 mm metalised OPP
Condiments	0.48 mm metalised PET/1.5 mm MDPE
Cask Wine	2 mm ionomer/0.48 mm metalised PET/3 mm EVA
Cookies	OPP/metalised 0.8 mm OPP
Medical Products	11.8kg paper/0.8 mm metalised OPP/ionomer

Table 2-16: Typical laminates using metalised films (Soroka, 1995)

2.2.5. Flexible Laminated Packaging

The purpose of laminated packaging is to combine the best of properties into a single laminated flexible packaging structure. The general properties of these types of packages is shown in
Table 2-17.

Property Type	Examples
Structural	Physical strength, elongation and puncture.
Performance	Machinability and sealability.
Barrier	Moisture, gas, odour, UV light
Aesthetic	Clarity, opacity, feel, metallic appearance
Cost	Required performance in specific time

Table 2-17: General properties of laminated materials (Soroka, 1995)

These packages have a huge variety of packaging applications. The combinations include the majority of the plastics outlined in section 2.2.2; the papers outlined in section 2.2.1 and the metal foils outlined in section 0 and will depend entirely on the required properties of the package.

2.2.6. Glass Packaging

Glass is a very common and old form of packaging. Glass is inert to most chemicals. Foods do not attack glass, nor do they leach out materials that might alter the taste. Glass's impermeability is especially important for long-term storage of carbonated goods and those goods susceptible to oxidation and moisture spoiling (Soroka, 1995). Glass is most readily used in the retail sector in one of three colours, flint, amber and green. Flint is the traditional clear glass, used for the majority of grocery packaging applications. Amber is the familiar brown glass. Amber is the only standard glass that filters out critical UV light (300nm) which is critical to the protection of the product. It is primarily for light sensitive products such as beer or pharmaceutical goods. Emerald glass is the bright green glass that is commonly found in the beer and wine heverage industry. Approximately 60% of all glass manufactured in NZ is supplied to the wine and beer industry (ACI NZ Ltd, 2000).

The most common package application for glass is in the bottle form. However, in the retail sector, glass can be found in wide mouth jar form or the narrow mouth form of the bottle.

2.3. Statistical Information

2.3.1. Research and Statistical Plan

In order for the design and testing of the methodology, the collection of data itself, analysis of data and presentation of data to be successful, a research plan needs to be derived. This is not just a consideration of the projects overall aim and objectives, it is understanding the detail and what exactly is required from a data point of view. Table 2-18 outlines the major steps involved in a large-scale quantitative data collection.

- Define the problem
- Define the exact information needs
- Set priorities on information
- Develop a research plan and budget
- Pilot/exploratory research (literature review, past projects)
- Conceptualise sampling methodologies
- Perform test collection and analysis
- Collect data

Table 2-18: Typical Steps involved in data collection research plan. (Holbert, 1993)

Once the steps of this plan are completed then the project itself becomes far easier to complete. (Holbert, Speece, 1993)

2.3.2. Sampling

Sampling is the title given to the method of reviewing a whole population by assessing a small percentage of it. The completion of reviewing a smaller sample of the whole population is statistically viable and far more resource and time efficient. Consider the following example: political polls are often measured using a sample size of one thousand. Based on research and statistical analysis it therefore justified for the researchers or statisticians to assume that the conclusions that they have found are an accurate approximation. If 200 of the one thousand respondents are in favour of a particular party then the researchers can assume that 20% of the nation, not the sample population are in favour of that party. Generally these polls have a 5% error associated with them. (Statistics NZ, 1998)

2.3.2.1. Sampling Issues

Within the general heading of sampling there are several issues that need clarifying before any sampling design can take place. (Holbert, Speece, 1993)

2.3.2.1.1. Target Population

The target population is the entire group from which we would ideally like to get information. The definition of the target population needs to be as exact as possible, such as, "All primary packaging that is visible without touch that is contained on the shelves in Pak N Save Palmerston North".

If information is also required for a subgroup of the population, a clear definition of that subgroup will also be required. (Holbert, Speece, 1993)

2.3.2.1.2. Survey or Testing Population

The survey or testing population is the group who has a chance of being selected as a part of the sample. Sometimes, for practical reasons the survey or testing population is not the entire target population. For instance, some surveys or tests are conducted by telephone but claim to measure the whole population. (Holbert, Speece, 1993)

2.3.2.1.3. Sampling Frame

Once the survey or test population is defined, the next step is to develop a means of accessing it. In its simplest form, a sampling frame is a list of elements covering the target population. Possibilities include:

- A physical list. For example, an electoral roll, a telephone, a computer printout of a membership list, a list of businesses.
- A conceptual list. For example, people booking airline tickets where certain proportion may be sampled to ascertain reasons for travel.
- An area frame. For example, geographical areas can from part of a multi-stage-sampling frame, with lists of dwellings for each selected area, and lists of people for each selected dwelling.

The following points are a guide to researchers for assessing whether or not their sampling frame is good enough to deliver the required level of accuracy.

- Each unit should be counted.
- Each unit should only be counted once. If some units are duplicated or counted twice then the results of the data collection will then be biased towards those samples that have been selected on more than one occasion.
- Each unit should be distinguishable from other units. If a unit is selected it should be easy to tell exactly what it refers to and it should be easy to be accessed.
- Up to date information should be provided. Product name, weights, origin etc. should be current. (Holbert, Speece, 1993)

2.3.2.1.4. Sample Selection

Sample selections principles can be summed up by saying that everyone unit of the population should have an equal chance of being selected. A sample that is selected based on known probabilities allows the results to be generalised and to have associated errors. To ensure that this does not occur, a randomised selection process needs to be developed. A common example of how to do this is to use a random number generator. If though, systematic sampling is been used where the sample is tested at every n^{th} unit then a random starting point will need to be generated.

The method of sample selection used will depend upon the information that has been targeted. The more complex the information needs are the more complex the selection process is. The use of statistically qualified personnel to collect data and assist in the data analysis is a wise decision. (Holbert, Speece, 1993)

2.3.2.1.5. Sample Size

Choosing the correct sample size for data collection involves considering such factors as:

- Resources: Time, money, equipment and personnel.
- Required Accuracy of results.
- The amount of detail needed in the results.
- The proportion of the population with the attributes been measured.
- The variability of the attributes being measured.
- The sample design used. (Holbert, Speece, 1993)

2.3.2.1.6. Sampling Strategies

There are two general types of sampling. These are probability sampling and non-probability sampling. In probability sampling, every unit has an equal chance of been selected.

Probability sampling methods include:

- Simple Random Sampling: selecting from a table of random numbers.
- Systematic Sampling: within the particular population that is chosen select one in every n^{th} unit to be tested and results gathered. When using this methodology a random start point also needs to be considered. It is often helpful to randomise the selection start point using simple random sampling outlined above.
- Cluster Sampling: can the data be broken into natural subgroups? If this can be done then the same secondary technique can be applied to each of the natural subgroups. This can often be classed as multi-stage sampling.
- Stratified Sampling: The population is divided into homogeneous or similar type groups. For example, if an investigation into softdrink consumption was to take place at Massey University then instead of using the population of Massey as a whole it can be separated into homogenous groups of either staff and students or into faculties. These groups (stratum) can then have different sampling methods are applied to each of them.

Non-probability sampling means that the chance of a unit being selected is not known. Therefore it is not possible in such cases to make any generalised statements about the population as a whole. (Department of Statistics New Zealand, 1992)

Non-probability sampling methods include:

- Haphazard sampling: There is no set out methodology used to select the units to be tested within the population.
- Sampling of volunteers: Asking volunteers introduces bias because they are not selected from a population.
- Judgement (purposive sampling): A sampling method where units to be tested are chosen by the worker using his or her judgement.
- Snowball sampling: The units selected indicate where further units can be found. This method is most commonly used in population studies. For example a selected unit may be a particular person who suggests that these people may be interested in completing the survey. (Department of Statistics New Zealand, 1992

2.3.3. Data Collection

The collection of data requires careful planning and testing to ensure that the data collection process is completed without error. If the proposal outlined in section 2.3.1 is completed and then confirmed by the personnel involved in the project, then the collection of the data can be completed with no large problems.

2.3.4. Data Analysis

After all the quantitative data is collected and coded, it must be analysed before it can become of any use in presenting the results of the data collection. The data analysis stage of the research process is itself a process. The key steps to the process are as follows:

- Determine what kind of data is available
- Decide what needs to be presented to the client in order to tell what the data shows
- Choose techniques to best get information on specific parts of what has to be presented tot he client
- Put the numbers into equations and calculate the results.
- Figure out what the results mean, what kind of patterns can be seen, what kind of statistical decisions should be made.
- Display or present the results in an orderly and clear fashion. It is often important to explain the results with real life implications as opposed to the use of a lot of numbers and statistical jargon. (Holbert, Speece, 1993)

Researchers must think about data analysis long before it needs to be completed. Data analysis is built around information needs. In every project that involves a large amount of data there are always four levels of data present. (Department of Statistics New Zealand, 1992)

2.3.4.1. Nominal Data

Nominal data is the term given to data that is completely arbitrary. These numbers are categories that represent the unit that are tested within the survey or sampling test. For example, student numbers, suppose one student has a student ID 96071736, then suppose a second student has the ID 96071730. No formal conclusions can be drawn from these numbers, because student one has a larger ID number than student two it does not mean that he or she is any more intelligent. However it may mean that this piece of data was registered first. These types of data are only ever used for identification purposes.

Nominal data is very important though. Its role in identification is as important as the data collected itself. Within a large set of data it is easier to draw conclusions and make assumptions if there is clear breakdown of the total population. Nominal data is also predetermined, therefore researchers doing the work will usually seek to obtain identification data before the frequency or the product weight. With large sets of data, using nominal data can help retrace or back looping in order to solve errors.

It is very important then to clearly identify what set of data or what category is your nominal data before commencing with any sampling.

2.3.4.2. Ordinal Data

Ordinal data is data that has categories that have some sort of particular order. Once the data is collected, it can then be ranked by a means of what ever is required or preferred by the project leader. Consider the following example in which four countries are going to be tested for tourist preference. In the first case the four countries were assigned a coding or identification number which is the nominal data value. (Table 2-19). However, the third column of Table 2-19 shows that after the data collection process has taken place the four countries can be rank in terms of preference as a tourist destination. This set of ordinal data indicates rank.

Country	Nominal	Ordinal
New Zealand	1	1
Australia	2	4
Western Samoa	3	3
Fiji	4	2

Table 2-19: Comparison of Nominal data to Ordinal data. (Holbert, 1993)

2.3.4.3. Interval Data

With interval data, the problem of scale is not present. A good example of interval data is temperature, where a measured reading of 30°C can be assumed to be exactly 15°C warmer than a reading of 15°C. However, if intervals of 20°C were used then the exact difference of the two readings could not be compared. The results however would be that one reading could fall in the interval 0-20°C while the second reading could fall in the 21-40°C interval

2.3.4.4. Ratio Data

Ratio data implies that assumptions like half as much or twice as much can be made. Money is a very good example of this kind of data. US$30 is exactly half of US$60. Interval data has no zero point or reference point, therefore these assumptions can not be made. (Holbert, Practical Market Research, 1993)

2.3.5. Data Analysis Techniques

2.3.5.1. Descriptive Statistics

Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with graphical analysis, they form the basis of virtually every quantitative analysis of data.

Descriptive statistics are used to present quantitative information in a manageable form. A research study may have lots of measures, hence, descriptive statistics help to manage and present the relevant data in an easier to read form. For example consider a simple number that is used to measure how well a batter is performing in baseball: the batting average. This single number is simply the number of hits divided by the total number of bats. A batting average of 0.33 describes that the batter is hitting one ball from every three that is faced. (Freund & Simon, 1997)

In descriptive statistics there are a variety of terms and jargon that are used. The following list of definitions is applied to all forms of descriptive statistics.

- Distribution: This is the summary of the frequency of individual values or ranges of values for a particular variable.
- Mean: This is the average, or means of describing the central most point of a set of data.
- Median: This is the exact value centre point of a set of data.
- Mode: The most frequently appearing value within a data set.
- Dispersion: This refers to the spread of the values around the central point. There are two common measures of the spread. These are the standard deviation or the range.
- Standard Deviation: This is a more accurate and detailed estimate of the dispersion because outliers can greatly bias the range value. The standard deviation shows the relation that a set of data has to the mean of the sample. (Freund & Simon, 1997)

2.3.5.2. General Linear Model

The General Linear Model (GLM) underlies most of the statistical analyses that are used in applied and social research. It is the foundation for the t test, analysis of variance (ANOVA), and analysis of covariance (ANCOVA), regression analysis and many of the multivariate methods including factor analysis, cluster analysis, multidimensional scaling, discriminate function analysis and canonical correlation. (Bates, 1988)

2.3.5.2.1. The Two-Variable Linear Model

The easiest point of entry into understanding the GLM is with the two-variable case. Figure 2-26 shows a bivariate plot of two variables. There may be any two continuous variables but, in the discussion that follows they will be referred to as a pre-test (on the x-axis) and a post-test (on the y-axis). Each dot on the plot represents the pre-test and post-test score for an individual. The pattern clearly shows a positive relationship because, in general, people with higher pre-test scores also have higher post-tests, and vice versa.

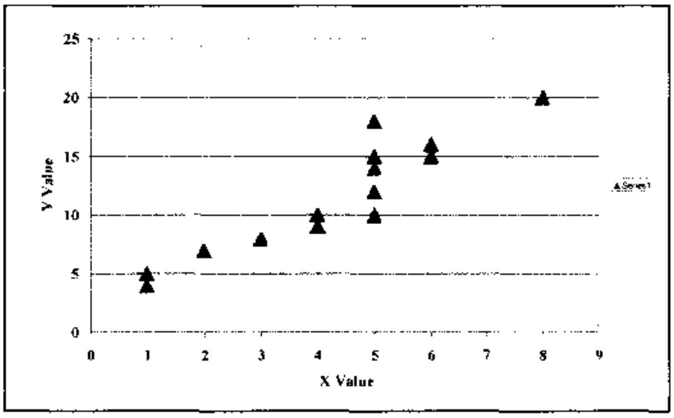


Figure 2-26: Bivariate Plot. A simple X, Y plot.

The goal in data analysis is to summarise or describe accurately what is happening in the data. Figure 2-27 shows that a straight line through the "cloud" of data points would effectively describe the pattern in the bivariate plot. Although the line does not perfectly describe any specific point (because no point falls precisely on the line), it does accurately describe the pattern in the data. When a line is fit to the data, it is using what is called a linear model. The term "linear" refers to the fact that a straight line. The term model refers to the equation that summarises the line that is fit. A line like the one shown in Figure 2-28 is referred to as a regression line and the analysis that it produces it is often called a regression analysis.

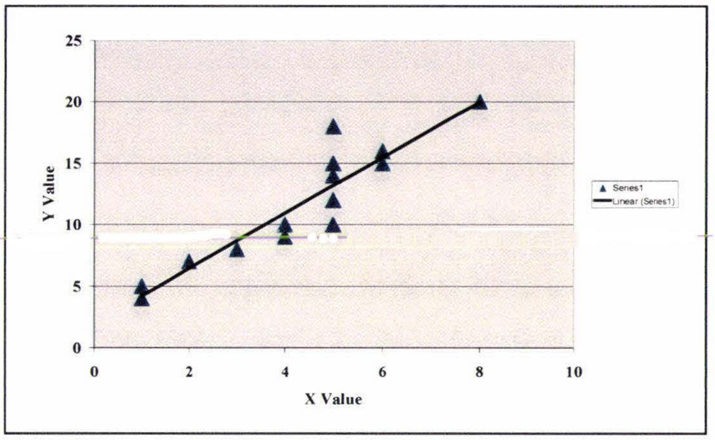


Figure 2-27: A straight-line summary of the data plotted.

Figure 2-28 shows the equation for a straight line. This equation is often stated in the form y = mx + b. In this equation, the components are:

- y = the y-axis variable, the outcome or post-test
- x = the x-axis variable, the pre-test
- b_0 = the intercept (value of y when x=0)
- b_1 = the slope of the line

The slope of the line is the change in the post-test given in pre-test units. As mentioned above, this equation does not perfectly fit the cloud of points in Figure 2-28. If it did, every point would fall on the line. One more component is needed to describe the way this line is fit to the bivariate plot.

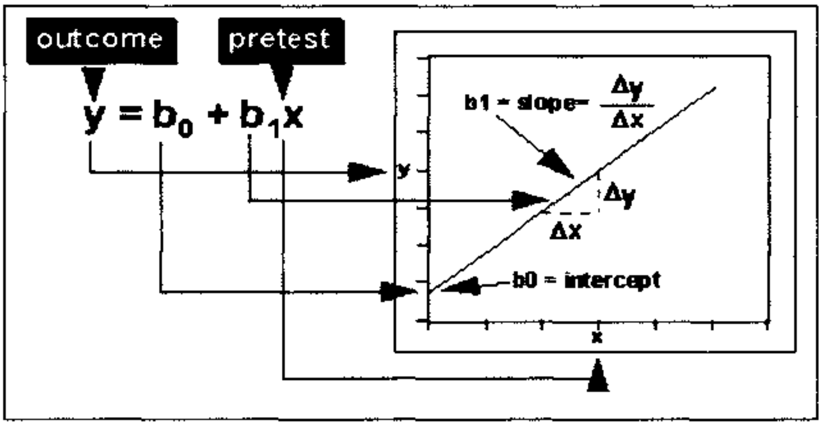


Figure 2-28: The straight-line model. (Britannica, 2001)

Figure 2-29 shows the equation for the two variables or bivariate linear model. The component that is added to the equation in Figure 2-29 is an error term, e, which describes the vertical distance from the straight line to each point. This term is called "error" because it is the degree to which the line is in error in describing each point. When a two-variable linear model is fitted to the data, it has an x and a y score for each unit in the study. The data values are inputted a computer program. The program estimates the b_0 and b_1 values for this plot as indicated Figure 2-29. The two numbers received back that are estimates of those two values.

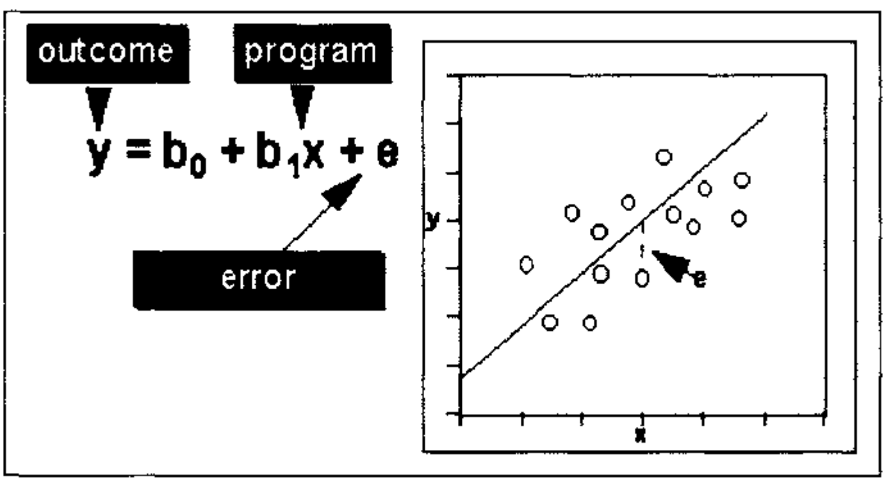


Figure 2-29: The two way linear models. (Britannica, 2001)

Two-variable regression line is like any other descriptive statistic. It is simply describing the relationship between two variables as much as a mean describes the central tendency of a single variable. And, just as the mean does not accurately represent every value in a distribution, the regression line does not accurately represent every value in the bivariate distribution. Summaries show the general patterns in the data and allow easy descriptions of these patterns in more concise ways than showing the entire distribution allows.

2.3.5.2.2. The General Linear Model

Given this brief introduction to the two-variable case, the model can be extended to its most general case. Essentially the GLM looks the same as the two variable model shown in Figure 2-29, it is just an equation. But the big difference is that each of the four terms in the GLM can represent a set of variables, not just a single one. So, the general linear model can be written:

$$\mathbf{y = b_0 + bx + e}$$

Equation 2-2: The GLM equation (Britannica, 2001)

where:

- y = a **set** of outcome variables
- x = a **set** of pre-program variables or covariates
- b0 = the **set** of intercepts (value of each y when each x=0)
- b = a **set** of coefficients, one each for each x

The GLM allows a study to be summarised for a wide variety of research outcomes. The major problem for the researcher who uses the GLM is model specification. The researcher is responsible for specifying the exact equation that best summarises the data for a study. If the model is mis-specified, the estimates of the coefficients (the b-values) are likely to be biased (i.e., wrong) and the resulting equation will not describe the data accurately.

The GLM is one of the most important tools in the statistical analysis of data. It represents a major achievement in the advancement of social research in the twentieth century. (Britannica, 2001)

2.3.5.3. Non-linear Regression

When data departs more or less from linearity, considerations into fitting another curve, rather than the traditional straight line must be made. There are three common non-linear plotting techniques. They are the parabola or two-degree polynomial regression, power or exponential regression and the logarithmic regression analysis. Parabola curve fitting is associated by Equation 2-3 shown below.

$$\mathbf{Y = cx^2 + bx + a}$$

Equation 2-3: Polynomial curve fitting equation (Freund, 1997)

It is also common practice to plot paired data on different kinds of graph paper to see whether there are scales for which the points fall close to a straight line. If this is the case when a semilog paper is used then it can be assumed that an exponential curve in present. Equation 2-4 shows the equation for a standard exponential curve

$$\mathbf{Y = a * b^x}$$

Equation 2-4: A power or exponential curve (Freund, 1997)

Or in logarithmic forms

$$\mathbf{\log Y = \log a + x * (\log b)}$$

Equation 2-5: Alternative Logarithmic function(Freund, 1997)

Equation 5 is a linear equation in x and y log, where log stands for logarithmic to the base 10.

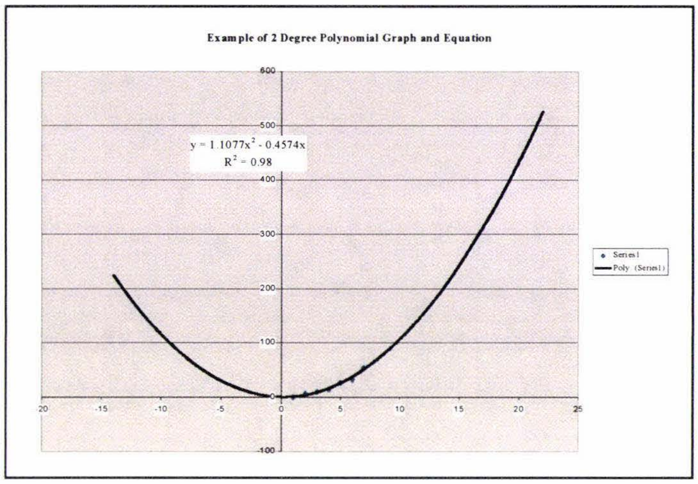


Figure 2-30: Example of a 2-degree polynomial regression.

Figure 2-30 shows that use of fitting a trendline or line of best fit using Microsoft Excel. This example shows how the points are plotted into a scatter plot and how the line is fit to the points. The programme can then be run and the output is the equation shown on the graph in Figure 2-30. The same methodology can be applied for more complex sets of data. Those requiring either a log function or an exponential function can be plotted using Microsoft Excel. Figure 2-31 and Figure 2-32 show a logarithmic function and an exponential function respectively.

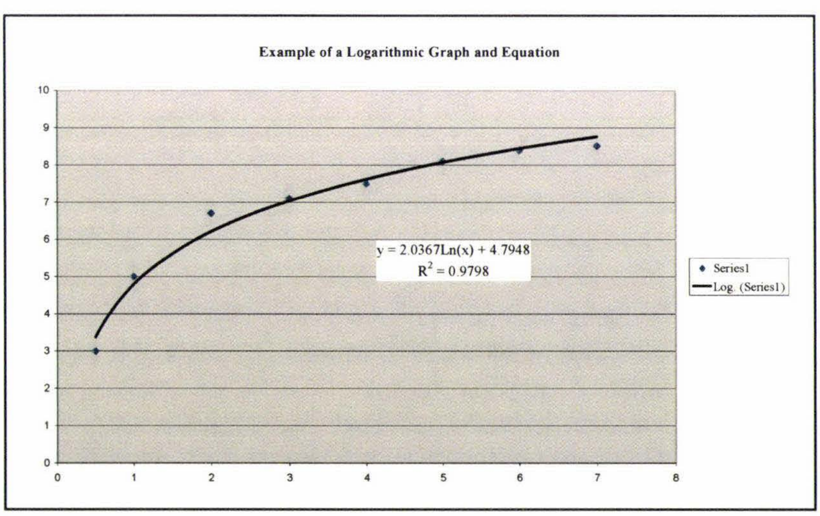


Figure 2-31: An example of a logarithmic regression. (Excel, 1997)

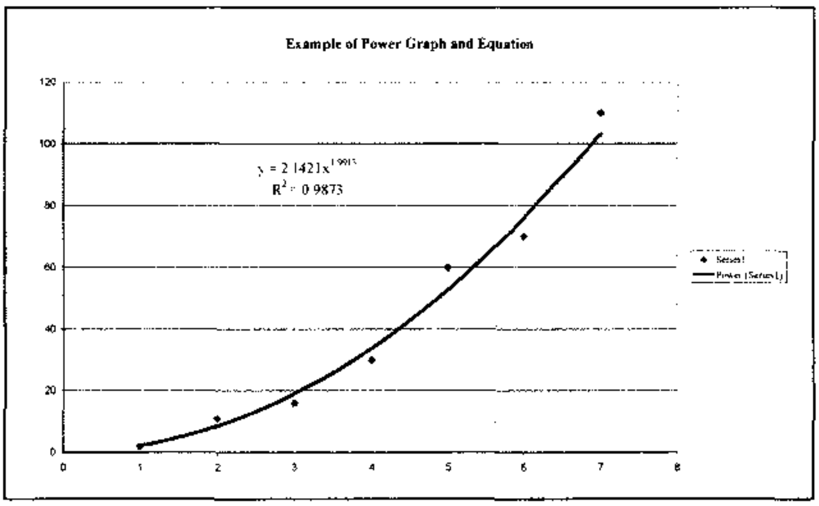


Figure 2-32: An example of power regression. (Excel, 1997)

Chapter 3. Project Methodology

3.1. Aim

The aim of this chapter was to break the project down into workable tasks taking into consideration the constraints involved in the project.

3.2. Methodology

After consultation with the Packaging Council of New Zealand the general overview and concept of what was required was defined as:

> "To develop and use a system that would estimate the total volume of retail packaging in New Zealand for the year to date, also considering the total proportion of what packaging is imported and what is manufactured in New Zealand"

The project methodology would consist of the following 3 main sections of work.

3.2.1. Task Breakdown

Task breakdown was a culmination of answering the three following questions

- What was required in order to fulfil the requirements of the client?
- Was the project able to be broken down into workable tasks?
- Was the project broken down far enough so it can easily be managed in terms of money and resources?

From section 2.1.2.2 of the literature review it was decided that the using a Work Structure Breakdown was the best possible method for determining the tasks of the project. It provided a structured breakdown of what was required and at a level of detail that allowed flexibility in the design of the system.

A further in-depth breakdown of the tasks was completed using the conversion diagrams. The reason for this was that the conversion diagrams provided an identification of the resources that each task requires the constraints that will restrict the task and the desired output of each task. (Refer to Conversion Diagrams file on Appendix CD provided)

The third and final step of the project breakdown was to generate flow charts that show the sequential tasks of each major sub tasks.

The tasks that are required for the sampling flowcharts, shown in Figure 3-3, were derived from the mechanisms that control the throughputs or sampling section of Figure 3-2. For example: In order to run good experimental design some initial research into sampling would need to be completed. Then testing would need to be completed, checked and formalised before the actual process of data collection could take place.

3.2.2. Resource Management

Because this project was based around the design of a retail packaging volume measurement system, the use of trial and error became an important factor. This allowed decisions to be made based on the outcomes of the trials. Also co-operation from external packaging firms and information providers meant that the project was dependent on their response.

The literature review touched upon three different methods that are regularly used for projects and project managers when evaluating time management for a project.

The Gantt Chart was the most suited tool for this project. Because this project had never been run in the past there was no history to draw upon. The Gantt chart gave this project the ability to shift tasks and their times easily, whereas the Critical Path Method requires a holistic approach to time management. CPM would be more aligned with creating efficiency within a system that has been completed in the past.

However because this project was primarily about creating a new system then the CPM is not suited.

PERT was also considered, however because of its close relationship with CPM and its non-illustrative format it was not suited for this project.

Microsoft Project was used as it allowed the project to estimate time required for tasks and illustrate in a variety of forms. Another benefit of Microsoft Project has the ability to add in resource use and the sub tasks that were needed to complete each stage of the project.

3.2.3. Project Flow Chart

A generic flowchart that will outline the major stages of the project was developed and is shown in Figure 3-3

3.3. Results

Figure 3-1 provides a Work Structure Breakdown for this project, which considers all the possible tasks that needed to be completed. At this stage it was important to include even those tasks that were required even if later in the project it was discovered that they were not needed. In this example the WSB is only two levels deep. Going only 2 levels down gave the project enough detail to work through on but not too much detail where the project becomes too restricting and no longer flexible.

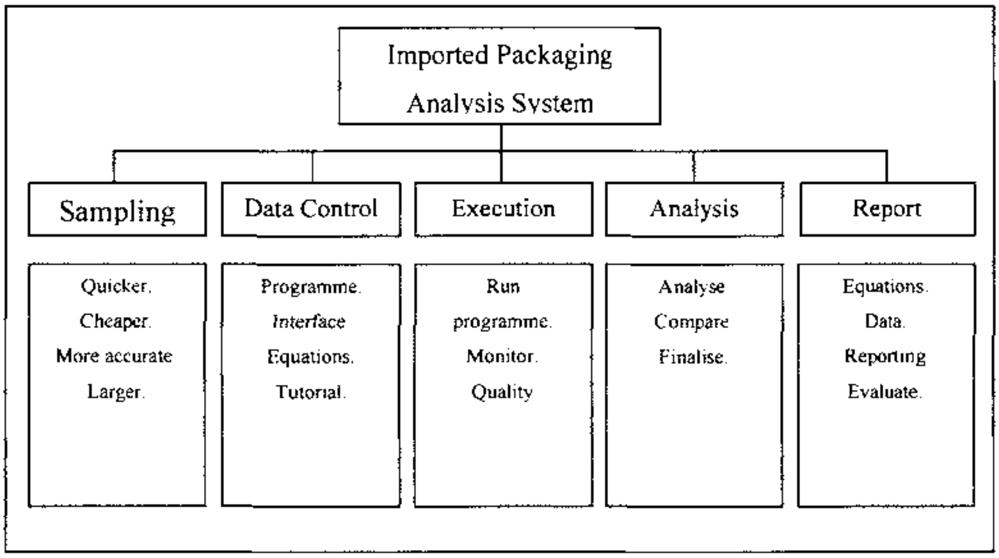


Figure 3-1: WSB to 2 levels for project methodology.

The conversion diagram was used for all the stages in the project. Figure 3-2 is an example of a completed conversion diagram. It expresses the inputs, the throughputs and the constraints that were applied to the sampling stage of this project.

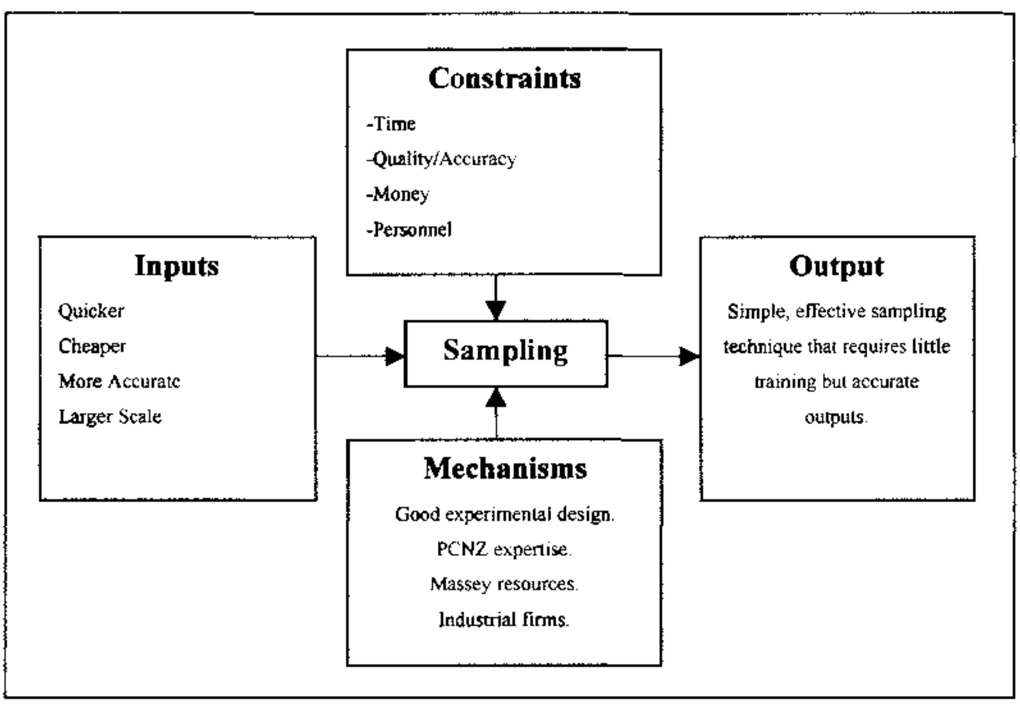


Figure 3-2: Conversion Diagram for the sampling section of the project

Figure 3-3 shows the flow diagram for the sampling stage of the project. A decision loop was added to ensure that the best methodology was accepted. This decision was based on time and resource consumption. It also provided the client and any other supervisory staff the opportunity to have input that altered certain aspects of the design. From a project management standpoint it was a way of guaranteeing that the work expected to be completed was equal to that of the client involved in the project.

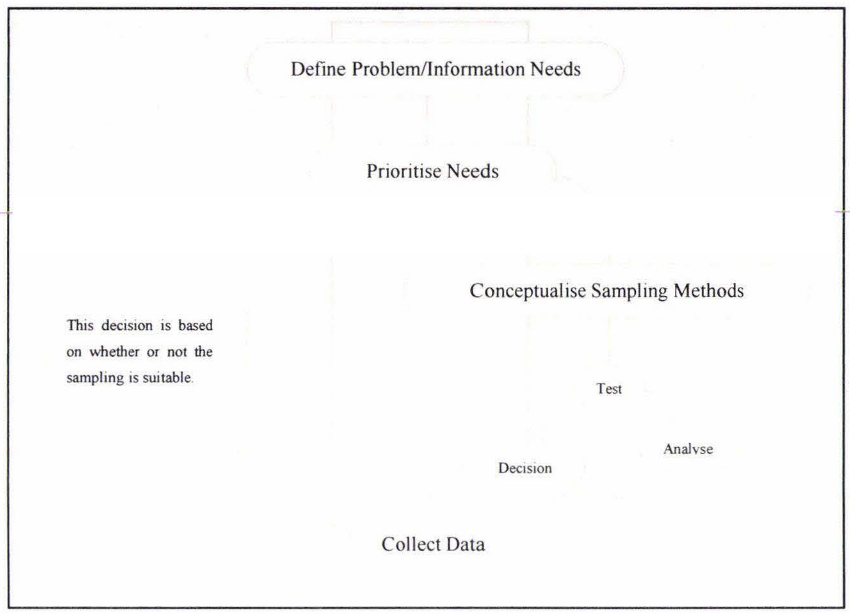


Figure 3-3: Sampling Flow Diagram.

3.3.1. Constraint Analysis

3.3.1.1. Financial Constraint

The Packaging Council of New Zealand Inc (PCNZ inc.) funded the project expenditure. The following limitations were put on the project before commencing.

- A maximum of $6000 for total labour costs.
- A maximum of $1000 for expenses and administrations costs.
- The PCNZ Inc. agreed to pay for the University fees. A total of $2100.00.

3.3.1.1.1. Financial Breakdown

Table 3-1 is the breakdown of the labour costs and how the allotted funds were used.

Labour Expenditure	
Income	$6000
Personnel Rate	$10 per hour
Total Hours	600 hours
Staff Numbers	4
Hours per Staff	150 hours

Table 3-1: Expenditure and time breakdown for labour costs.

3.3.1.2. Required Information Constraint

New Zealand Packaging expertise were accessible through the Packaging Council of New Zealand Inc. with the only constraint been confidentiality which require confidentiality agreements

3.3.1.3. Personnel Constraint

No prior training or qualification was required to complete the sampling work; therefore, the work that was offered was perfect for part time students at Massey University.

3.3.1.4. Time Constraint

The project needed to be completed thoroughly and within an initial expected time of 12 months. Figure 3-4 is the Gantt chart for the project. It shows the major tasks and the timeframes that are associated to them.

ID	Task Name	Start	Finish
1	Project Management	Mon 26/06/00	Tue 8/08/00
2	Sampling Design	Wed 9/08/00	Wed 20/09/00
3	Data Collection	Thu 21/09/00	Thu 8/02/01
4	Data Analysis	Fri 9/02/01	Wed 11/04/01
5	Coversion Rate Design	Thu 12/04/01	Thu 24/05/01
6	Collaberate Results	Fri 25/05/01	Thu 21/06/01
7	Write Procedures Manual	Fri 22/06/01	Thu 19/07/01
8	Presentation	Fri 20/07/01	Thu 26/07/01
9	Writing Thesis	Mon 3/07/00	Fri 3/08/01

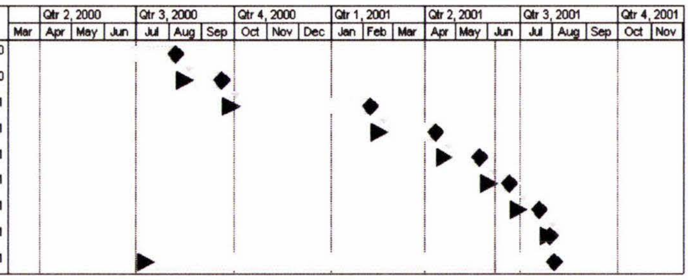


Figure 3-4: Gantt Chart produced in Microsoft Project.

3.3.2. Project Flow Chart

Project flowchart Figure 3-5 is the result of the WSB.

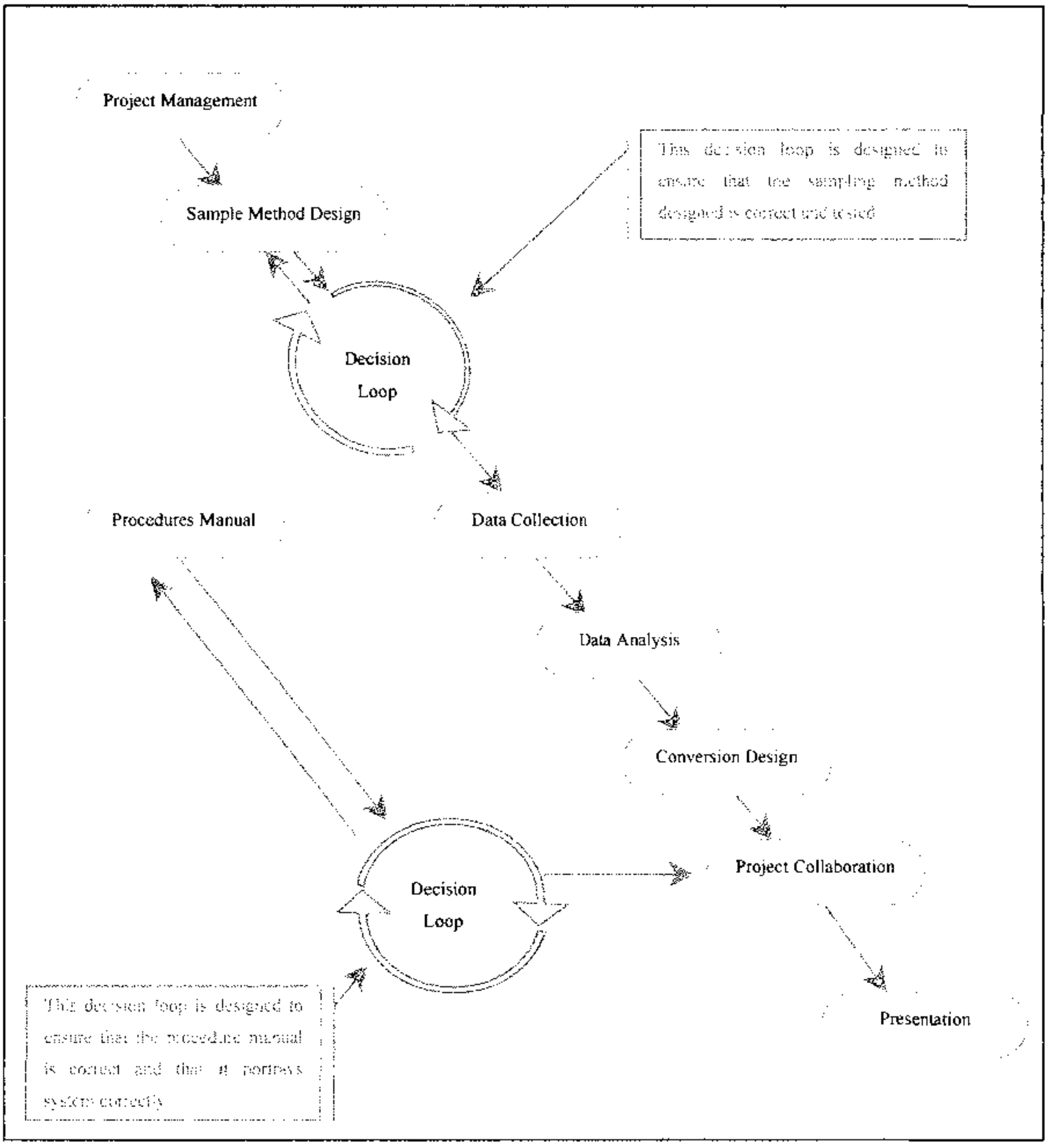


Figure 3-5: Overall project Flow Chart

3.4. Summary

This chapter has bought the project to a point where by it was ready to begin. Initially the Work Structure Breakdown (Figure 3-1) was used to identify the key steps in the project. The conversion charts were then utilised to provide driving mechanisms and to create awareness of what resources need to be used. (Figure 3-2)

With the use of Microsoft Project the project could be laid out, into the form of a Gantt Chart. (Figure 3.4) Lastly this chapter was designed to overview the complete project and the main steps that would need to used in order to complete it. This process is shown in Figure 3.5.

Chapter 4. Sampling Method Design

4.1. Aim

This chapter develops the sampling method that was used to:

- Be quick and efficient when repeated in the future years.
- Use less labour and monetary resources than in the past.
- Easy to learn, teach and use.

4.2. Methodology

The design of an effective sampling methodology requires the use of a the Research and Statistical Plan outlined in section 2.3.1 in the literature review. (Shown in Figure 4-1)

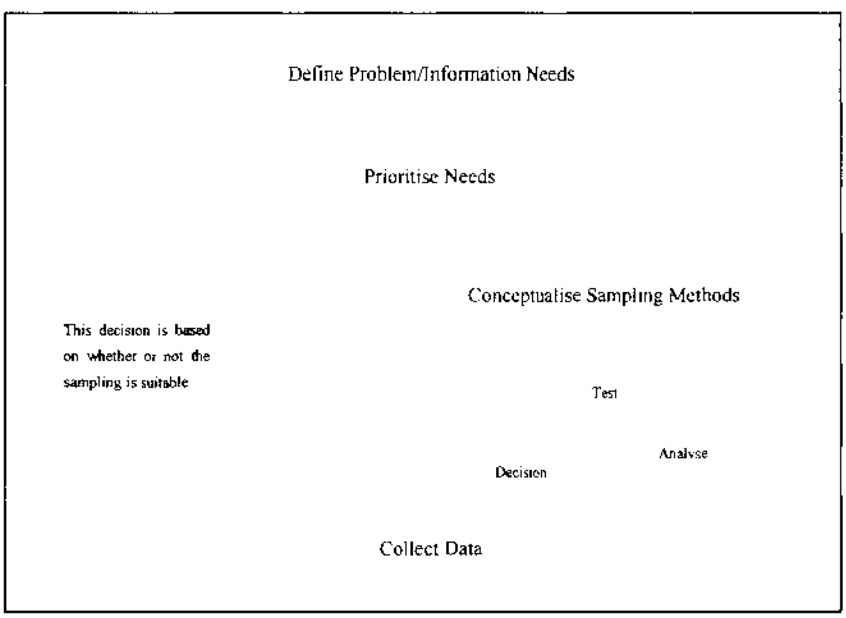


Figure 4-1: Flow Chart of Sampling Design.

Once the plan and identification of the needs was completed the design of a sampling methodology was completed. This consisted of two separate design stages. The first was the design of the sampling method. Secondly the determination of the amount of packaging for each product. For example, consider a can of fruit, what was the best method to estimate the package weight of this product?

These two separate designs were then tested and the results were combined to find the method that encompasses the best sampling time and the best accuracy.

4.3. Results

4.3.1. Definition of Problem

4.3.1.1. Primary Problem

The Packaging Council of New Zealand requires a total tonnage figure of retail packaging in New Zealand.

4.3.1.2. Secondary Problem

There are a number of secondary problems in order to achieve the primary problem. These are:

- A proportion of imported retail packaging versus that that is manufactured in New Zealand.
- The categorical makeup of the tonnage by a packaging type. i.e. what percentage is paperboard, what percentage is glass, metal etc.
- The total figure should be divided into areas of retail. This means grocery, general mechandise and bottle store packaging.
- The data should indicate proportion of primary versus secondary packaging.

The system had been designed in order to achieve firstly the initial problem, but in designing the system, consideration should also be made towards achieving the secondary problems. If this could be achieved then the PCNZ will have a greater understanding on the retail packaging market than just a total packaging figure.

4.3.2. Information Needs

The information that was required in order to complete the project was:

- Decision on which stores were going to be used for this project
- A list of all the products from the chosen stores
- An estimated or calculated weight for each package of the list
- National sales data for the year previous to the commencement of this project.

Using data collected from Woolworths, The Warehouse and Liqour King provided this project with a large percentage of the retail market in terms of volume. However the use of Pak N Save would further reinforce the band of data used.

What data is required from each product in order to determine the total volume? Each product needed to be assessed in order to gain an accurate estimate of the total weight of retail packaging.

The package weight would need to be multiplied by a yearly sales figure. This would provide the best estimate of total weight of the packaging disposed in that year.

4.3.3. Prioritisation of Needs.

The prioritisation of needs is based on the section 2.3.2.1 of the literature review.

4.3.3.1. Target Population

The target population was chosen based on the fact that the majority of retail products are sold in these four stores. The Department of Statistics New Zealand assesses retail expenditure in New Zealand. The general categories of expenditure are titled grocery and food, general merchandise and alcohol. Therefore the selection of The Warehouse as a general merchandise store, Woolworths and Pak N Save as grocery stores and Liquor King as a bottle or alcohol store was made.

The target population for this project was:

- **The Warehouse**. The Warehouse offers a huge variety of general merchandise.
- **Woolworths**. Woolworths was used because of the diverse variety of grocery goods that are sold.
- **Pak N Save**. Pak N Save offers less variety in terms of product but holds a far larger volume of product.
- **Liquor King**. Liquor King stocks all New Zealand manufactured beverages. As a large-scale chain store it also boasts a large variety of imported product.

This is the makeup of the total population to be investigated. Each and every product in these stores will need to be considered and have an equal chance of been amongst the data that is collected.

4.3.3.2. Testing Population

Unfortunately every product needs to be assessed, although the final design of the methodology may not require all of the products in these stores.

4.3.3.3. Sampling Frame

The sampling frame is based on the section 2.3.2.1.3 of the literature review.

The sampling frame for this project was created as the data collection is completed. Each product is identified so nominal data such as bar code, product name and product size could then be recorded. The sampling frame will need to be completed to ensure that the database can be referred to easily at a later date.

4.3.3.4. Sample Selection

The following sample selection methods were evaluated to select the most appropriate method:

- Simple Random Sampling
- Cluster Sampling
- Stratified Sampling

4.3.3.5. Sample Size

The sample size was estimated to be 68,200 products between the four stores selected[2]

Store Name	Estimated Size
The Warehouse	45000 different SKU's
Woolworths	12000 different SKU's
Pak N Save	10000 different SKU's
Liquor King	1200 different SKU's

Table 4-1: Estimated proportion of products in the four stores[2]

[2] the estimations of the four stores were quoted from management representatives of the stores indicated.

4.3.4. Sampling Methodology Design.

4.3.4.1. Aim

To design and test three sampling concepts for data collection. The design must consider the reduction of time and monetary resources, it should also consider the future use of the methodology to repeat the project. This means that the results of the sampling should be able to be put into a database and be able to be referred to in the future.

4.3.4.2. Methodology

- Brainstorming ideas for data collection methodology
- The sampling methods were tested over a range of 30 different products.
- The test consisted of collecting the following pieces of nominal data for each of the thirty products.
    - Product name
    - Department of store
    - Bar code or stock code
    - Product weight or millage
    - Packaging type
    - Any other details considered important.
- Screening the methods down to one functional concept using criteria that measures the time taken to complete the collection of the nominal data.

4.3.4.3. Design Results

4.3.4.3.1. Design One: Every Product

Design one is collecting both the nominal and the ordinal data from every single product in the stores.

Obviously, sampling every product will be a hugely time consuming tasks. However, the data this method would provide very accurate results and possibly the closest result to the true volume of packaging.

4.3.4.3.2. Design Two: Every n^{th} Product

Design two would be to collect data based on systematic sampling outlined in section 2.3.2.1.6 of the literature review.

This method would reduce time and monetary resources considerably, however it would not take into account different package weights. For example if one in every ten products from the toy section of The Warehouse was collected then the total weight of the packaging would be biased because of the huge variation packaging types. Assessing one in every ten does not consider the fact that each product has a variation in the package type.

4.3.4.3.3. Design Three: Two-Stage Design.

Design three is a two-stage design that was derived from the previous two concepts. Stage one is establishing what primary packaging each and every product has. This will form clusters of products with similar packaging types. Then the second stage will be selecting from within each of the clusters generated through stage one using a systematic method. (eg. one in every five products.)

This method will allow an increased level accuracy due to the measuring of a larger proportion of the products. This will allow the database to have every product listed but less products tested to generate relationships to represent the clusters and represent the clusters.

4.3.5. Product Package Analysis Methodology

4.3.5.1. Aim

To design a methodology that can analyse the weight of product packages in an efficient time whilst maintaining the accuracy needed for a total estimate of the volume of retail packaging.

4.3.5.2. Methodology

- Brainstorming used to generate ideas on how to analyse the packages.
- Methodologies were developed from the ideas generated in the brainstorm.
- The methods were tested over a range of 30 different products.
- The methods were screened down to one functional concept using criteria that measures the time taken to collect the data.

4.3.5.3. Design Results

4.3.5.3.1. Design One: Dimensional Analysis

Design one is an exact replica of previous method to evaluate imported retail packaging in 1998. This method uses conversion rates to estimate the package weight of a particular product. The method requires the collector to measure the product's package dimensions for the conversion rate.

For example, a can of Watties Baked Beans would need to be measured for its area, which is then multiplied by a conversion rate that represents the weight per area of the metal used for the can. The data collector would measure the two circles at the top and the bottom and the height of the cylindrical body of the can. These dimensions would be recorded along side the nominal data collected previously.

4.3.5.3.2. Design Two: Net Gross Weight Analysis

Design two involves determining the gross weight of the product. The total weight of the package can be estimated by subtracting the net weight from the gross weight. Using this information regression analysis can be performed.

4.3.6. Testing Results: Sampling Methodologies

4.3.6.1. Nominal Data Collection Test (ND)

Table 4-2 shows the results of the first test, as predicted design 2 was definitely the quickest. Designs 1 and 2 were remarkably slower as Table 4-2 indicates.

Sampling Test: Results from 10/09/2000		**Total Time Taken (mins:secs)**
Design One	All 30 products	11:50
Design Two	All 30 products	11:50
Design Three	1 in every 10. 3 Products	1:40

Table 4-2: results of sampling design tests.

4.3.6.2. Test Results: Product Package Analysis (PD)

Table 4-3 shows the results of the time taken to analyse 30 products using product package analysis methodologies outlined in 4.3.5. From the table it is obvious to see that design one is certainly long winded compared to the time taken in design two.

Package Analysis Test: Results from 10/09/2000		Total Time Taken (mins:secs)
Design One	All 30 products	24:00
Design Two	All 30 products	13:00

Table 4-3: Results of measurement to determine amount of packaging.

4.3.6.3. Combination of the Test Results

The data collection of this project will be a combination of the two separate designs. ~~The total time of the various combinations is shown in Table 4-4.~~

Combination	Total Time (mins:secs)
ND1 and PD1	35:50
ND1 and PD2	20:50
ND2 and PD1	3:50
ND2 and PD2	2:30
ND3 and PD1	16:10
ND3 and PD2	14:26[3]

Table 4-4: Combination of sample and package analysis times.

If accurate output is wanted then assessing one in every ten products is not the best solution. The reason for this is because of the huge diversity in the packaging range.

[3] The combination of ND3 and PD2 is 14:26 because ND3 has two stages. The second of which is only a proportion of the total number of products analysed. ND3 requires one in every five packages to be tested. Hence the total time is ND2 + 0.2(total time of PD2).

Every package differs slightly from the next, thus, assuming that every tenth product is a fair representation of the total population.

4.4. Outcomes

The outcome of this section of work is the sampling and package analysis method to be used in the data collection in the four retail stores.

The method to be used is a combination of sampling design three and product package analysis design 2. The times taken in the combination tests showed that it was clearly quicker and therefore will be used to collect the raw data.

The final method consists of the following steps:

- Select every product that is in the store.
- Record the following nominal data for each product.
    - Product name
    - Department of store
    - Product weight or millage
    - Any other details considered important
    - Package type

Once this stage is completed then data collected can be sorted in clusters that are created based on the data under the title of package type. Once they are sorted the next stage can be completed using the following steps.

- Weigh the product and its package as one.
- Subtract the volume and grammage from the total weight to give the estimated package weight.

There are several considerations that will need to be made in order to justify this methods use. These are:

- The weight on the label on the product will be assumed to be the true weight of the product in the package. Thus a 60-gram packet of crisps will contain 60 grams of product.
- Volume will be converted to weight using the theory of one millilitre of water weighs one gram. Hence, a 500-ml bottle of coke will contain an estimated 500 grams of product.
- Some products will not have this sort of information labelled on it. Hence, those products will be assessed using dimensional analysis or will be issued an average value for that particular cluster. This approximation will be assessed later in the thesis.

4.5. Summary

This chapter outlines the research plan. It covered the sampling issues that surround the data collection and what effects that might have on the design of the sampling and product package analysis methodologies.

This chapter also outlines the design of the methodologies and the testing of them. After initially designing three different methods for collecting the nominal data and designed two methods for assessing the packaging of the products, testing proved that a combination of sampling every product for it's nominal data and its package type was the best means the data collection.

There was however some assumptions that needed to be made in order for the method to be usable.

Chapter 5. Method Execution

5.1. Aim

The aim of this chapter was to collect all the necessary data in order to make an accurate estimate of the total volume of retail packaging in our waste stream. Secondly, this chapter was also dedicated to making continuing improvements to the sampling and package analysis methodology discussed in the previous chapter. These improvements needed to be made in order to improve time efficiency, resource use, staff morale and the accuracy of the results.

5.2. Methodology

The methodology of this chapter was designed to not only assess all the raw data needed for this project but also assess the process itself and generate better methodologies for future reference.

The first two stages of the process were administrational issues. These however play a pivotal role in the data collection process. Gaining permission from stores to collect data is very important. Without this support the project could not be completed. The second issue is to find reliable staff that are willing to assist in the completion of the tasks.

The problem-solving loop in this process was designed to improve the process at any given point. If either staff or management raise a particular issue then this will be assessed and a solution would be designed. The completion of the data and the completion of the continuous improvement of the process would only be satisfied if the complete process is accepted by the project manager. (Refer to Figure 5-1)

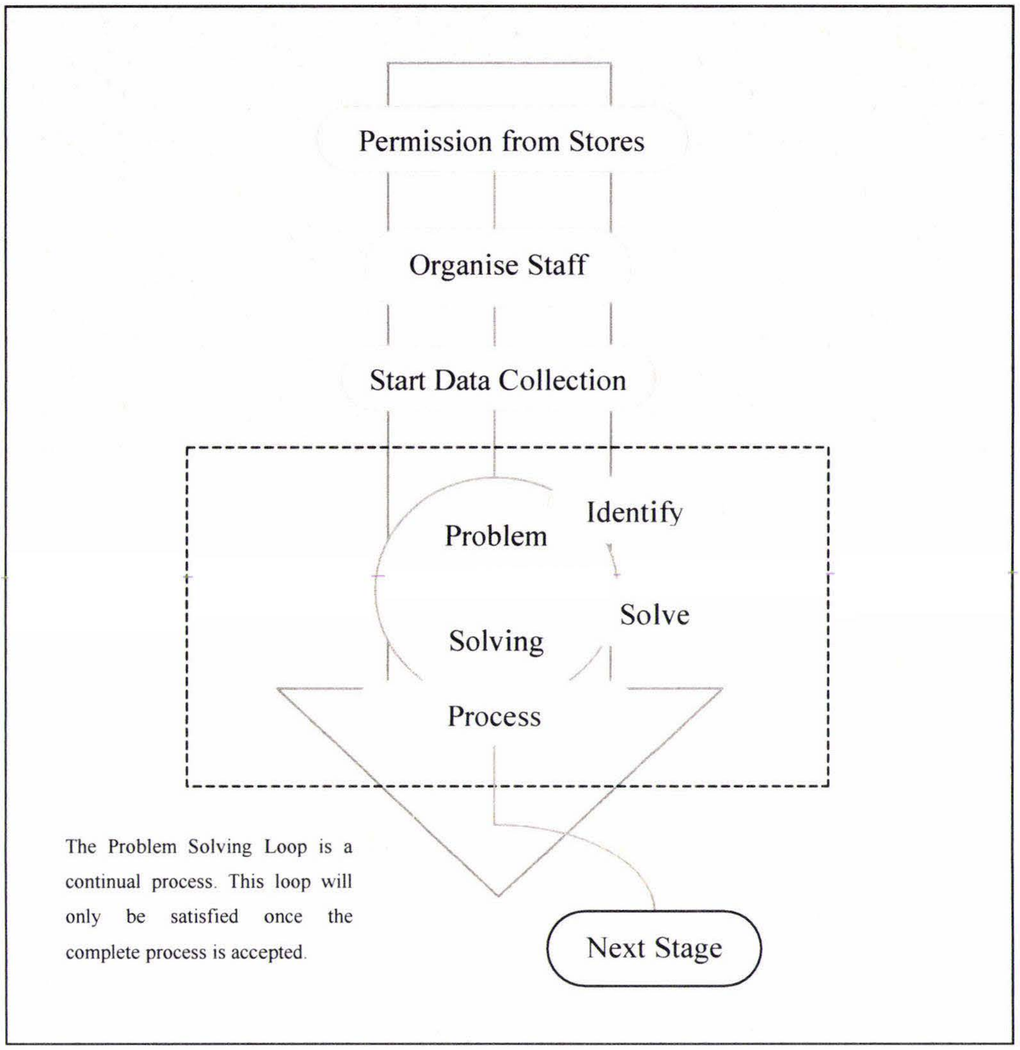


Figure 5-1: Process Diagram of Data Collection Methodology

5.3. Results

5.3.1. Permission of Stores

Woolworths, Pak N Save, Liquor King and The Warehouse all granted permission to be involved in the project. Each store gave the project an appropriate time to collect data and a set of rules that were signed and agreed upon by project leaders.

5.3.2. Data Collection Process

Refer to Section 4.4 for method to be used initially.

5.3.3. Problem Solving Loop

5.3.3.1. Iteration #1: Access to Store Printouts.

5.3.3.1.1. Problem Identified

After three hours of data collection, it was obvious that the process of taking down the nominal data for each and every product was going to a very lengthy process. The collection of data at this point was in the wine section of Woolworths. It had taken three hours to complete 90% of the wine section. Proportionally this is 2.6% of the total number of products in Woolworths. Extrapolating that out to represent the total number of products meant that it was going to take 7680 hours to complete the store.

5.3.3.1.2. Revised Solution

After consultation with management staff of Woolworths it was discovered that the use of store stock list printout would reduce the time to complete the first stage of the process considerably. Further consultation with the remaining three stores meant that is was possible to get printouts of the stocklists for all the stores involved.

Once the printouts were received, the first stage of the data collection become a far quicker process. The wine section of Woolworths was recollected and completed in less that 1 hour under the new process with the printouts.

5.3.3.2. Iteration #2: New Zealand or Foreign Product

5.3.3.2.1. Problem Identified

The second problem that was identified was that neither the original process nor the printouts that were obtained had a description of the product origin. One of the requirements of this project is to analyse the total proportion of imported packaging. Without some sort of identification data variable this task becomes impossible.

5.3.3.2.2. Revised Solution

To combat the identified problem an extra column was placed onto the outside of the printouts. In this column and for each and every product an N for New Zealand made or an F for foreign made packages and products.

5.3.3.3. Iteration #3: Package Identification Nominal Data

5.3.3.3.1. Problem Identified

After completing Woolworths it was apparent that clusters based on packaging material were appearing. Throughout the collection of the data it became obvious that a coded system of some sort would eliminate some of the time collecting the nominal data and the product package analysis.

5.3.3.3.2. Revised Solution

A coding system for the package type was drafted using the data gathered from Woolworths grocery store. Table 5-1 shows the categories identified and labelled.

Packaging Nominal Code	Package Material	Example of Product
1	Plastic Film	Frozen Vegetables, Bread
2	Plastic Container	Ice Cream
3	PS Tray and Plastic Film	Meat Products
4	Plastic Bottle	Beverages
5	Paper	Flour
6	Paper Foil	Freshup, UHT Milks
7	Corrugated Cardboard	Toys
8	Solidfibre Board (SFB)	Baking Goods
9	SFB +Plastic	Stockings
10	Glass Bottle	Beverages, sauces
11	Glass Jar	Meal bases
12	Tin Can	Fruit and Vegetable
13	Tin Tube	Tomato Paste
14	Sachet	Soups
15	Foil	Frozens
16	Other	Non determined

Table 5-1: List of Packaging Material Coding System.

Packaging Nominal Code 16 (PNC16) was used for those products where the package was unidentifiable for the researcher. Once the data collection of each store was completed the project leaders reassessed all products labelled PNC16 and issue these products their correct packaging nominal code.

The second stage of the data collection, analysis of the product package is completed using either the net gross method, or the conversion method. Each of these methods requires the collection of particular pieces of data. What is required in terms of each type of package is outlined below in Table 5-2

Packaging Nominal Code	Primary Dimensions	Secondary Dimensions
1	Gross Weight or Volume	Surface Area
2	Gross Weight or Volume	Surface Area
3	Surface Area	
4	Volume	
5	Gross Weight or Volume	
6	Gross Weight or Volume	
7	Surface Area	Weight or Millage/Thickness
8	Surface Area	Weight or Millage/Thickness
9	Surface Area	Thickness
10	Volume	
11	Gross Weight or Volume	
12	Gross Weight or Volume	Surface Area
13	Gross Weight	Surface Area
14	Gross Weight	Surface Area
15	Gross Weight or Volume	Surface Area
16	N/A	

Table 5-2: Dimensional analysis for PNC 1 through to PNC16.

5.3.3.4. Iteration #4: Extra Nominal Packaging Codes

5.3.3.4.1. Problem Identified

Once collection of data recommenced, it was discovered that there were several types of material and combinations of materials that were identified. On previous occasions these packages had been treated as separate materials.

5.3.3.4.2. Revised Solution

Table 5-3 shows the categories that were added at the commencing of data collection of Pak N Save.

Packaging Nominal Code	Package Material	Example of Product
17	Aerosols	Fly Spray
18	SFB/Can	Beverage
19	SFB/Glass Bottle	Beverage
20	SFB/Plastic Bottle	Beverage
21	Plastic Bottle/Plastic	Beverage
22	Aluminium Can	Beverage

Table 5-3: Second iteration of Packaging Nominal Code.

Originally, aluminium cans were sectioned with tin cans. After considering the difference in the packages and the differences in the relationship between grammage and package weight, both of these materials were split up into separate categories.

The remaining additions were based on packaging combinations between beverage packaging the boxes that the cans or bottles came in. These were added to the end of the list of categories. Each of the new categories in the PNC needs to have the primary and secondary dimensions added to it so that the second stage the sampling methodology can be completed. Table 5-4 shows the codes and the dimensions that will need to be recorded during the data collection.

Packaging Nominal Code	Primary Dimension	Secondary Dimension
17	Gross Weight	
18	Surface Area	Volume
19	Surface Area	Volume
20	Surface Area	Volume
21	Surface Area	Volume
22	Volume	

Table 5-4: Dimensional analysis for PNC 17-22.

5.3.3.5. Iteration #5: Packaging Code 9 Expansion

5.3.3.5.1. Problem Identified

During the collection of data at the Warehouse very definite packaging types were identified for PNC9 (A combination of Solid Fibre Board and Plastic). Three types of packaging were identified and commonly seen throughout all the departments of the store. After a brief review of the data collected at Woolworths and Pak N Save it was identified that these types of packaging were common amongst these stores also. PNC9 was broken down into sections that would be easier to measure and evaluate at later stages of the project.

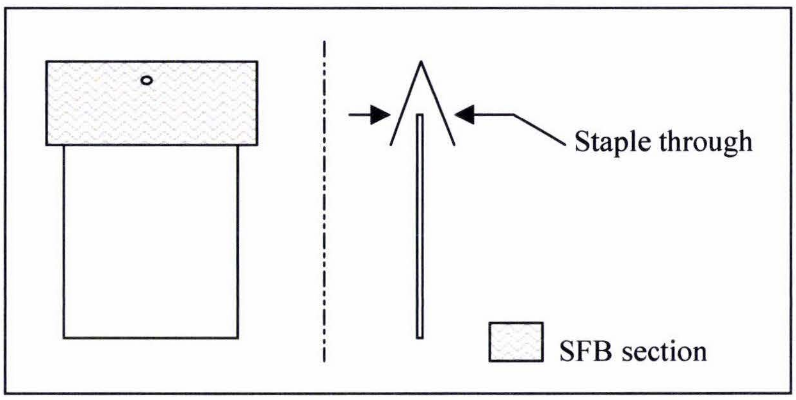
5.3.3.5.2. Revised Solution

The revised solution to the problem was to split PNC9 into three very different package types. Each is made up of the SFB and plastic in some way but each type is very different in the way the materials are combined.

The first of the three types was labelled PNC9Ax. Figure 5-2 is an example of PNC9Ax packages.

Figure 5-2: Common examples of 9Ax packaging.

The 9 in PNC9Ax refers to the fact that the package is defined as a combination of both SFB and plastic film. The A from 9Ax refers to the type of combination of packaging and the way in which the materials are combined. In this case the packaging has SFB at the top and the plastic in a bag shape press between the layers of the SFB. Figure 5-3 below is a schematic of this type of packaging. Lastly the x in PNC9Ax refers to the size. At this stage it is guesswork but there appears to be very definite steps between sizes. This will be confirmed later when conversion rates and package weights will be analysed.



The second of the packages to be analysed is PNC9Cx. Where the 9 is a representation of the combination of SFB and plastic, the C refers to the type and the x is a variable for the size similar to that expressed for PNC9Ax. Figure 5-4 shows common retail example of this type of packaging.

Figure 5-4: Common example of a PNC9Cx package.

PNC9Cx packages are built from a SFB backing board and have formed plastic stuck to the front covering the product like the schematic shown below in Figure 5-5

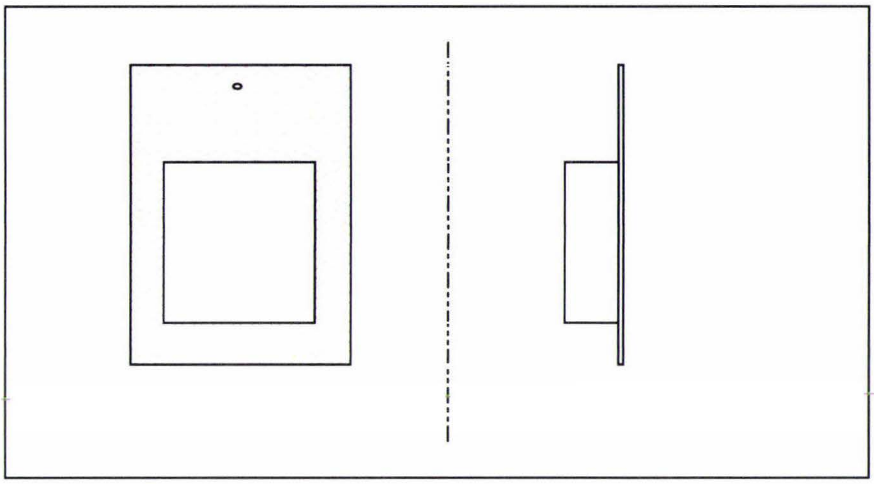


Figure 5-5: Schematic of a 9Cx package.

The last of the packages is PNC9Ex, where the 9 refers to the combination, the E refers to the type and the x is the size variable. Some common retail examples are shown below in Figure 5-6.

Figure 5-6: Common example of PNC9Ex packages

PNC9Ex packages are different in that they do not bind through or to the SFB in the package. The SFB in these packages is only used as a printing medium. Each of these packages is hinged with two section of plastic. The tops of the packages are stuck together with a male female plug that is moulded in to the individual section of the plastic. Figure 5-7 below shows how the packages are brought together to house a product.

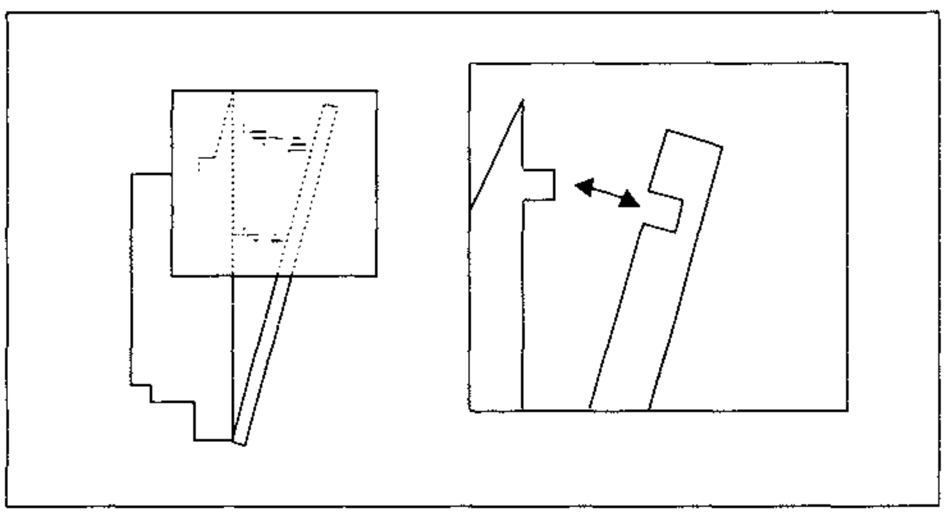


Figure 5-7: Schematic of a PNC9Ex package.

In terms of the second stage of analysis, these packages were assessed in the same way, measuring the surface area. When recording the data, this product will have a measured SFB area and a measured plastic area.

5.3.3.6. Iteration #6: Breakdown of Corrugated Board Packages

5.3.3.6.1. Problem Identified

During collection of data at The Warehouse it was noted that corrugated board packages differ from product to product. However, they only vary in three different packages. The first was simply a complete box, the second was a box with a window and lastly the third was a box with a plastic window.

5.3.3.6.2. Revised Solution

The solution to this problem was simply to revise the labelling of the PNC7 so that it represented the three different sorts.

In reference to the last stage of the data collection, these packages will need to be assessed in terms of the surface area. For 7B the data will need also to have an estimate of the area that the carton has as an open window. For 7BP the same estimate will need to be made but the area missing will need to be recorded as plastic. Table 5-5 below shows the data required in order for the analysis to be complete.

PNC7x	Primary	Secondary	Tertiary
7A	Area	Thickness	
7B	Area	Thickness	Area missing
7BP	Area	Thickness	Area missing

Table 5-5: Table of dimension needed for analysis of PNC7

5.3.3.7. Iteration #7: Breakdown of Solidfibre Board Packages.

5.3.3.7.1. Problem Identified

PNC8 was treated the same way as PNC7; the only difference is that they are different boards. However, changes need to be made in order to keep the different packages separate.

5.3.3.7.2. Revised Solution

The solution had the same process applied as PNC7.

PNC8A is a whole box but is produced from solidfibre board. An example of PNC8A is shown below in Figure 5-8

Figure 5-8: Example of a PNC8A package.

PNC8B is a boxed package using solid fibre, only a section of the front is missing for customer observations. An example of this type of package is shown below in Figure 5-9.

Figure 5-9: An example of a PNC8B package.

Finally PNC8BP is a box package with a removed section that is plastic. Figure 5-10 below shows a common retail example of this from of packaging.

Figure 5-10: Example of PNC8BP packaging.

The dimensional data collection for these packages will be completed as per Table 5-5.

5.3.3.8. Iteration #8: Breakdown of Plastic Film (PNC1)

5.3.3.8.1. Problem Identified

After a lengthy review of the data from The Warehouse a problem in the analysis of PNC1 was identified. There was no process for analysing products that were packaged in larger much more dense plastic film.

5.3.3.8.2. Revised Solution

The revised solution for PNC1 was to split the package type up into definite clusters. This was done through the analysis of those packages concerned. Using callipers and digital scales the following levels were found.

- PNC1A was a thin plastic film used to package lighter goods. Frozen vegetable, candles and the more standard plastic bags. This type of plastic was calculated to have an average grammage of 95gm^{-2}.
- 1B was simply double the dimensions of 1A with an estimated grammage of 191gm^{-2}. This form of packaging was used for slightly more industrial products like, gardening equipment and hardware.
- Lastly 1C was any plastic package that exceeded both the thickness and the GSM of 1A and 1B. It's grammage was calculated to be 286gm^{-2}

5.3.3.9. Iteration #9: Tag and No Packaging Identification

5.3.3.9.1. Problem Identified

For those products that either have no packaging or simply a tag, no nominal data label was given to them.

5.3.3.9.2. Revised Solution

For those products with no packaging, NP was entered onto the data sheets whilst the collection was taken place in the store.

98% of tags were SFB and under the weight of 16.25 grams. From retracing the products with tags, 2 definite clusters were formed. One around an average of 4.8 grams and one around an average of 10.28 grams.

The result of this analysis is that tags would be defined as either being a 5-gram tag or a 10-gram tag. When the product is analysed the nominal data variable be either 5T or 10T would be added in the PNC8 section of the report.

5.4. Outcome

There were two outcomes for this chapter.

The first of the outcomes is the data that was collected. This data can now be taken through to the analysis stage and conversion rates and equations can be formed. The data was also taken from hard copy and put into computer form. The information was entered into a spreadsheet and sorted into packaging nominal codes.

The second outcome of this chapter was the revised process. The new process requires the data collection to use printouts from the individual stores. The new process provides the same level of nominal information in a fraction of the time. The remaining changes to the process are primarily to do with nominal data input.

The revised process now looks like Figure 5-11 shown below.

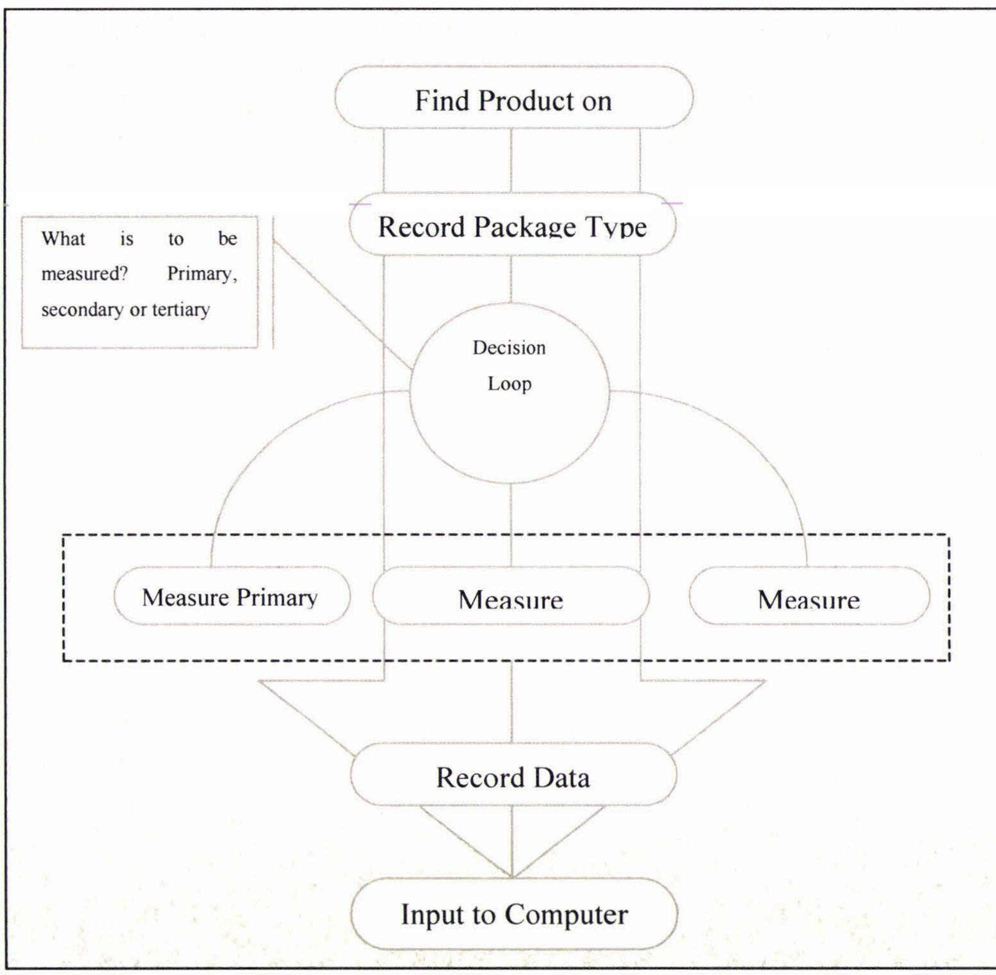


Figure 5-11: Revised data collection process.

5.5. Summary

This chapter reviews the process of data collection, and the continuous improvement of the data collection system.

After nine iterations of improvement the process was then evaluated and redrawn as shown in Figure 5-11.

This chapter aimed to improve the process in terms of resource use, accuracy of the information and sampling staff morale. In making the changes to the process through those 9 iterations, the process was made more efficient in terms of time spent to complete the data collection.

Chapter 6. Conversion Method Design

6.1. Aim

The primary aim of this chapter was to derive regression equations to calculate the weight of product packages from the data collected from the retail stores.

6.2. Methodology

Using the data collected from the four stores and in the literature review along with simple regression analysis outlined in chapter 2, relationships between product weight or volume and package weight were developed.

For some of the PNC the relationship developed is not in the form of an equation because of absence of any correlation between product weight and package weight. Hence these packages were given a conversion rate. Using an average thickness as opposed to a varying thickness and the equation derived by the data a conversion number can be derived. This value is a weight per area value. Therefore, for PNC 1,7,8 and 9 the total package weight is estimated by multiplying the conversion value by the surface area of the package.

The conversion rates and the regression equation analysis was completed using the process chart shown below in Figure 6-1

The decision loop that is in the flow chart is in respect to the acceptance of the conversion rate or equation, which depends on the level of confidence in the correlation coefficient or the error in the results of the test of the equations. The following assumptions were made prior to commencing with the methodology. Project Management and The Department of Statistics New Zealand Guidance Department accepted these assumptions as confidence levels for this form of data.

- A correlation coefficient greater than 0.80 will be considered a good fit.

- A correlation coefficient between the value of 0.7 and 0.8 will be considered a fair fit.
- The estimated data using these equations was then compared to a few packages that were weighed with out any goods in them. After discussions with the other stakeholders in the project an error of 12% was accepted with the knowledge of how difficult these estimations were.

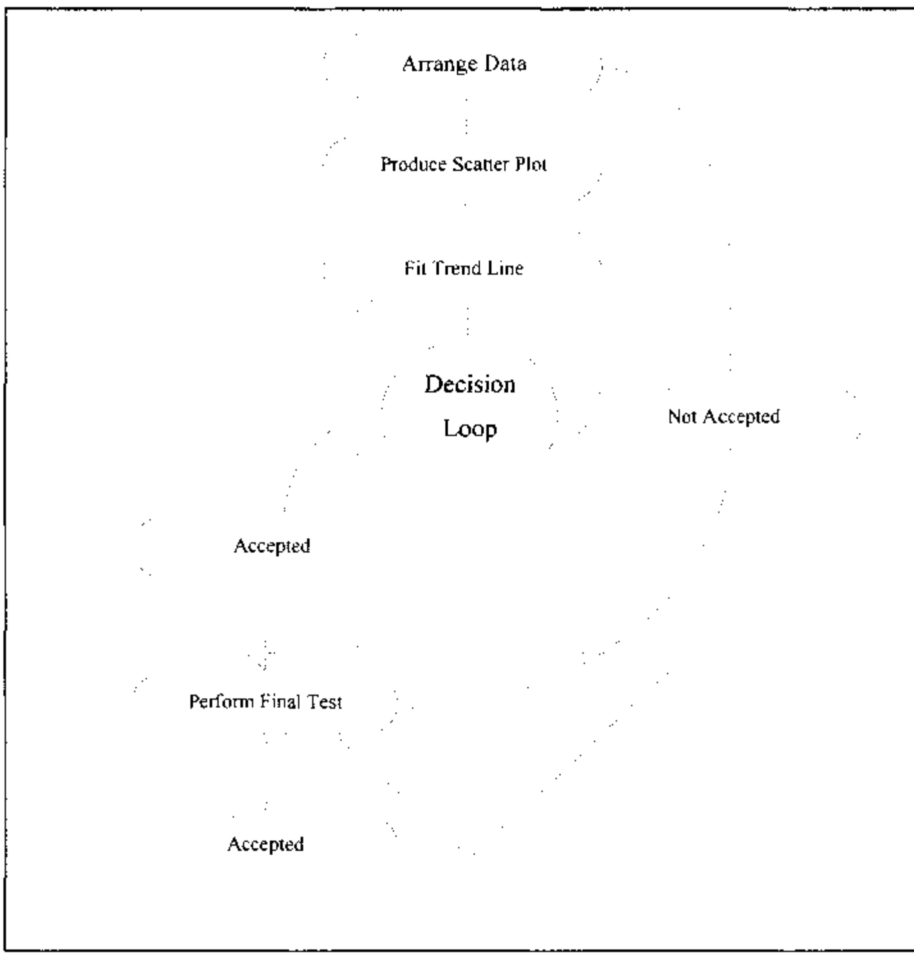


Figure 6-1: Flow chart of data analysis chapter

6.3. Results

6.3.1. Packaging Nominal Code 1: Plastic Film Packaging

Figure 6-2 below shows the relationship between the gross weight of the product versus the weight of the package measured in the data collection. The resulting R^2 value of 0.8095 would indicate the presence of a relationship. Thus, any package in PNC1 could be equated using this regression equation Y = 0.4741 * X ^ 0.6966.

Any product that has no product gross weight or volume on it was estimated using a conversion rate. This conversion rate was calculated using the average density of common retail packaging plastics and the proportional use of these plastics in North America. This information is outlined in section 2.2 of the literature review. Figure 6-3 shows the equations for PNC1A and PNC1B and PNC1C.

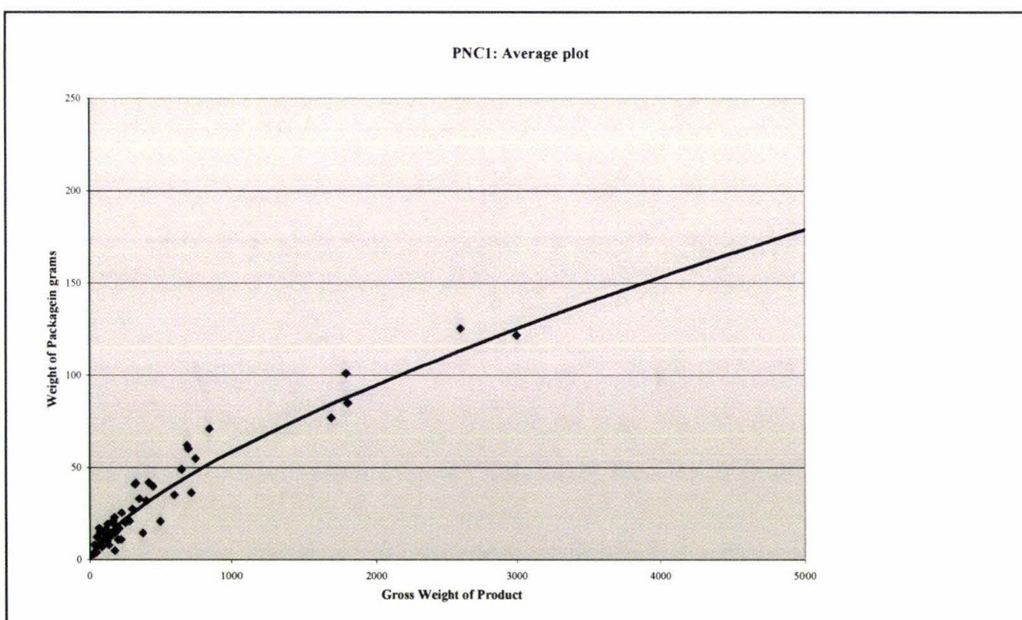


Figure 6-2: PNC1 conversion equation graph.

PNC1A	1. Y =2 *[95.58 * AREA]
PNC1B	3. Y = 2. [191.16* AREA]
PNC1C	4. Y = 2 . [286.74 * AREA]

Figure 6-3: Conversion equations for non-volume or non-gross weight labelled PNC1A, PNC1B and PNC1C products.

6.3.1.1. Data Comparison

The data comparison shows that there is a fair comparison between the estimated data and the actual measured data. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.2. Packaging Nominal Code 2: Plastic Containers

The correlation coefficient for PNC2 is 0.8414 shows a very good relationship between the product net weight and the estimated weight of the package. Therefore the regression equation Y = 0.9596 * X ^ 0.5823 was used to estimate the weight of the products in the target population that were not measured.

6.3.2.1. Data comparison

This package type is very regular in terms of shapes and sizes. The largest difference is in the thickness. Therefore there will be discrepancies and fluctuations in the errors. However the errors balance each other and there is enough accuracy to say that this equation is a fair fit. (Refer to Estimated vs Real Package Weight on the appendix CD)

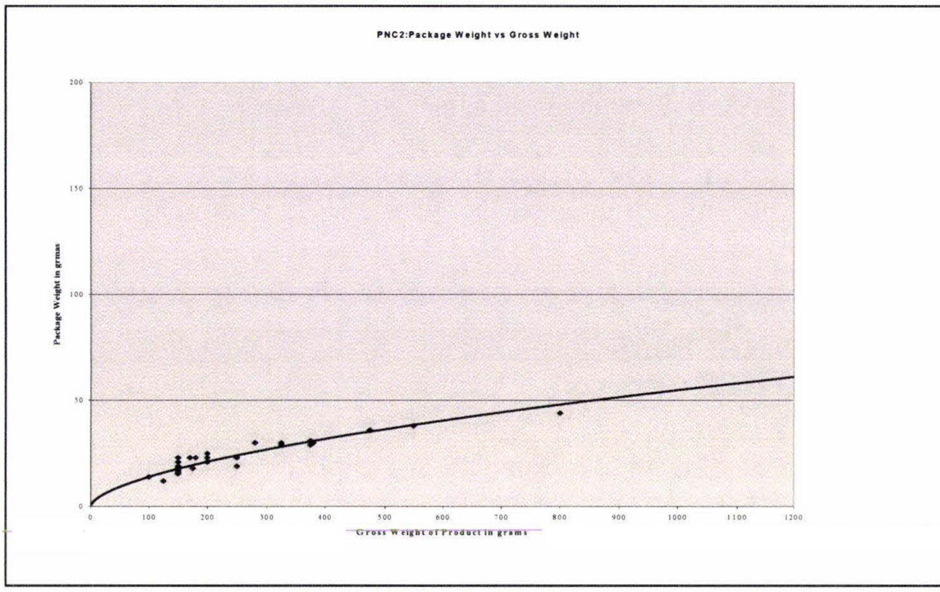


Figure 6-4: PNC2 conversion equation graph.

6.3.3. PNC3: Polystyrene Tray with Plastic Film

PNC3 is a specialised packaging group for products that are pre packed and kept fresh as grocery stores. The majority of PNC3 products are meat packages, thus they were categorised into small medium and large based on the area of the polystyrene tray. Several products from each package sizes were then weighed and the averages were calculated. (Shown in Table 6-1)

Package Size	Weight of Polystyrene (g)	Weight of Plastic (g)	Total Weight (g)
Small	24	8	32
Medium	27	9	36
Large	31	10.5	41.5

Table 6-1: Table of estimated average weights of PNC3 packages.[4]

1. [4] These averages are based on measurements carried out throughout the duration of the data collection. They are derived from sample sizes of n=30 and the results are round to 1 decimal place.

After investigating all the PNC3 packages it was discovered that there was generally only three sizes. Other produce such as vegetable and fruit are packaged with the same materials. Of the 250 products that were tested only 3 products packages fell outside the categorised small medium and large PNC3 packages.

Therefore all PNC packages are assigned the average value 36.5 grams.

6.3.4. PNC4: Plastic Bottles

Plastic bottles are one of the most common forms of plastic packaging. The majority of plastic bottles are labelled with volume but some that are labelled in grams. This section looks at those that are labelled with volume or millilitres. Figure 6-5 shows the bivariate plot for this set of data. However, the accuracy of the measure is decreased by the fact that different shapes and different types of bottles require more or less plastic. For example, looking at 1000, 2000 and 3000mL bottles there are a large range of products over the one volumetric value.

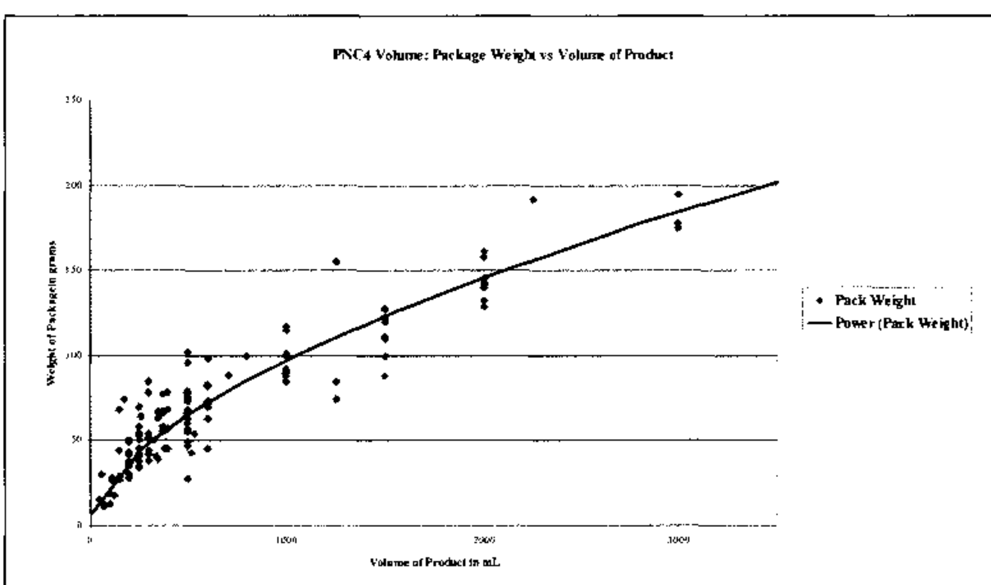


Figure 6-5: PNC4 volume conversion equation graph.

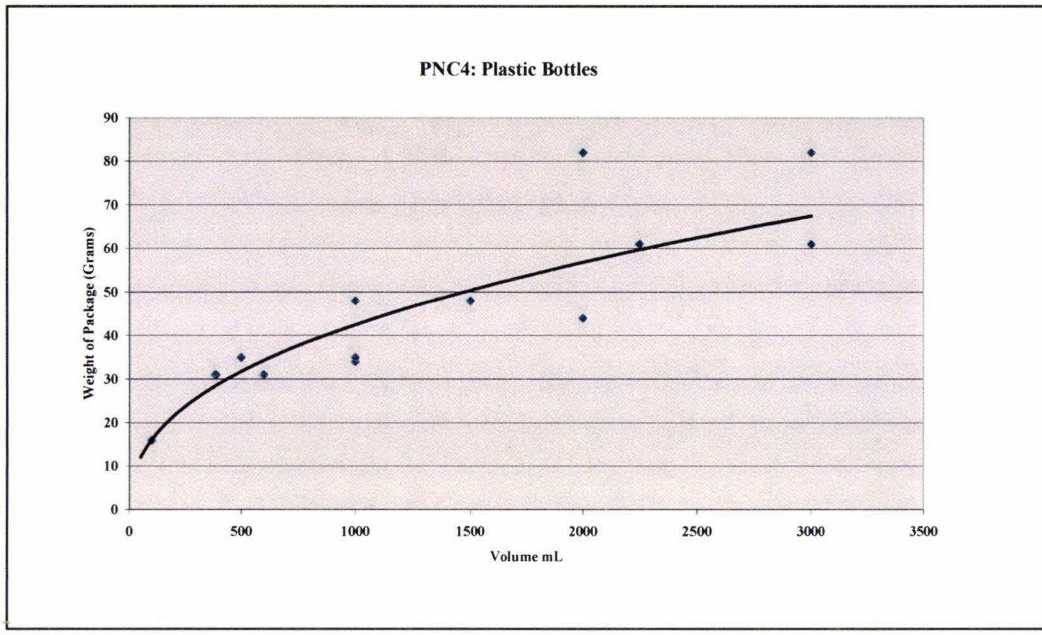


Figure 6-6: Plot using empty bottle weights.

However there were issues with the accuracy of this data. The reasons for this may have been overfilling at the manufactures. Thus empty bottles from various sizes were measured without any contents and the data was plotted. The results show that there was a variation in the data. This was corrected by using the new equation from the new data. (Figure 6-6)

6.3.5. PNC5 Paper Packaging

Figure 6-7 shows the plot for PNC5. The correlation coefficient of 0.9712 would indicate that there is a clear linear relationship between the gross weight of the product and the weight of the package. The regression equation Y = 0.0454 * X + 11.741 was used to estimate the package weights of the non-sampled products.

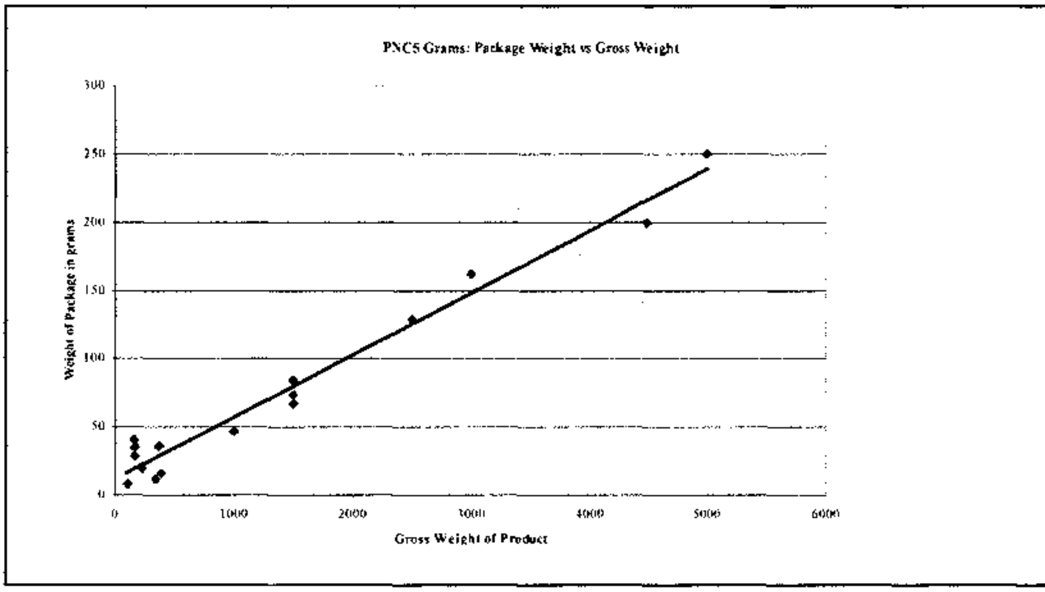


Figure 6-7: PNC5 conversion equation graph.

6.3.5.1. Data Comparison

Paper packaging was difficult in the sense that there were very few packages. Of those that there were, some were at the 100 to 1000 grams gross weight range while the packages like the 5kg Dog Biscuit Bags were at the other end of the scale. When applying the best-fit line the variations in the data meant that there were over estimations at the bottom end while at the top there were underestimation. Thus the final error is being a relatively small net error.

6.3.6. PNC6 Paper Foil Laminated Packaging

Figure 6-8 shows the plot of the weight of the product versus the estimated weight of the package. The resulting correlation coefficient of 0.9712 reinforces the closeness in the relationship. Thus, the regression equation Y = 16.787 * e ^ (0.0016 * X) was used to estimate the package weights of those products that were not sampled.

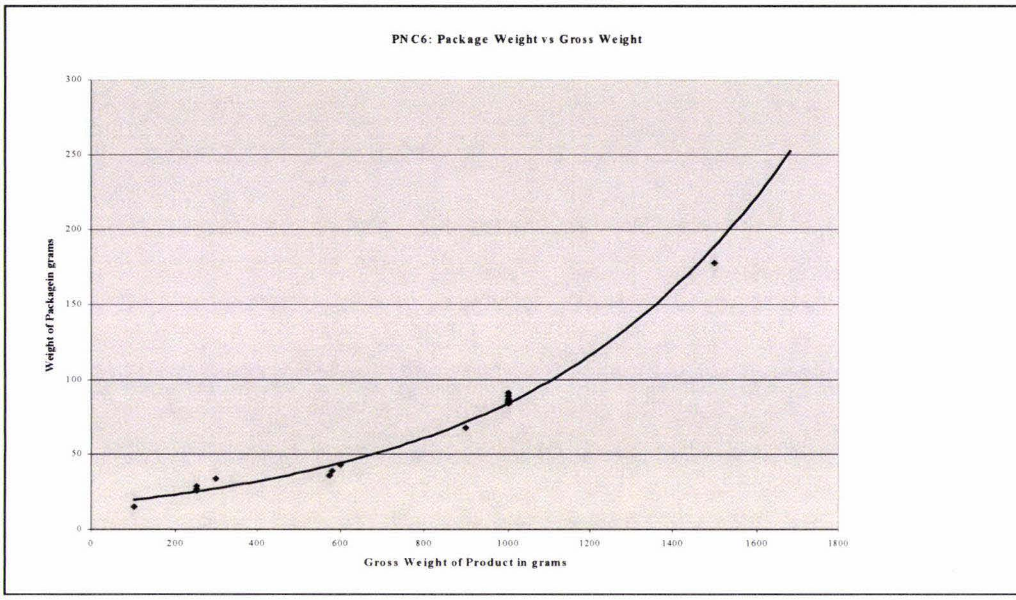


Figure 6-8: PNC6 conversion equation graph.

6.3.6.1. Data Comparison

The errors here were again skewed a little by the variation over the complete weight range of the products. However the bulk of the volume is in the 500ml to 1000ml range and the error rate in this range was stable at 9% (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.7. PNC7 Corrugated Board Packages

PNC7 is the one of the largest packaging sectors in the retail industry being used primarily as a secondary source of packaging. In some cases though, for example larger goods such as toys and furniture packaging, PNC7 is predominately used as the primary form of packaging.

The first step in estimating or deriving a conversion equation for PNC7 was to complete an analysis of several different types of boards found in the retail sector. Carter Holt Harvey corrugated were approached for information in regard to the thickness versus the GSM of the boards manufactured in New Zealand.

Figure 6-9 shows the average plot of those boards that are manufactured in New Zealand.

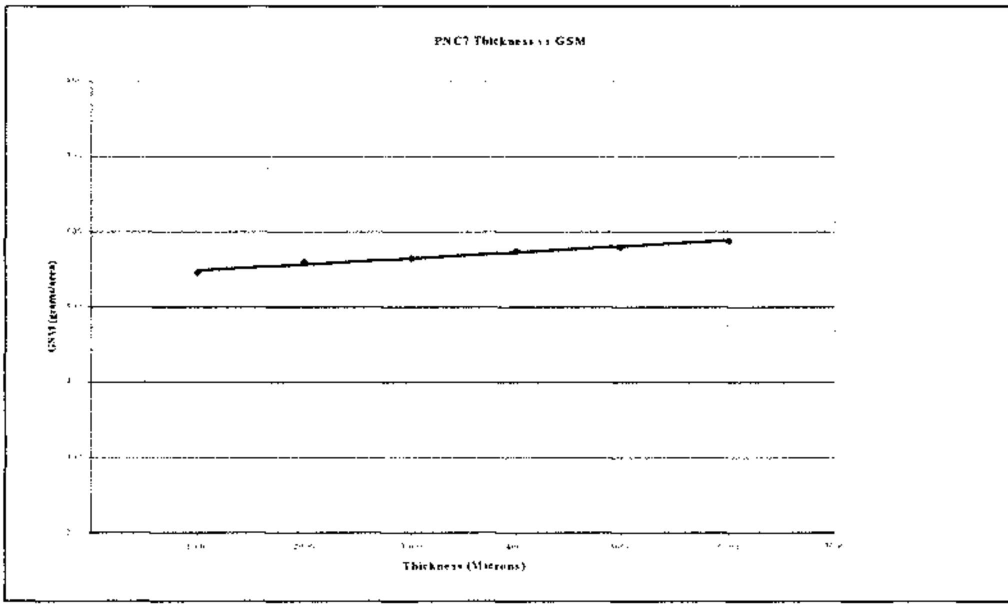


Figure 6-9: Average plot of New Zealand manufactured corrugated boards.

During the data collection of this project it become apparent that corrugated boards varied minutely in terms of their thickness. There were however some cases of micro fibreboard that were obviously thinner. From Figure 6-10 the inter-quartile range was spaced over less than 1mm. That means that 50% of the population is within 1mm. The whole population is within 2mm of each other. Because this distribution appeared to be relatively normal an average value was used to represent the whole thickness population.

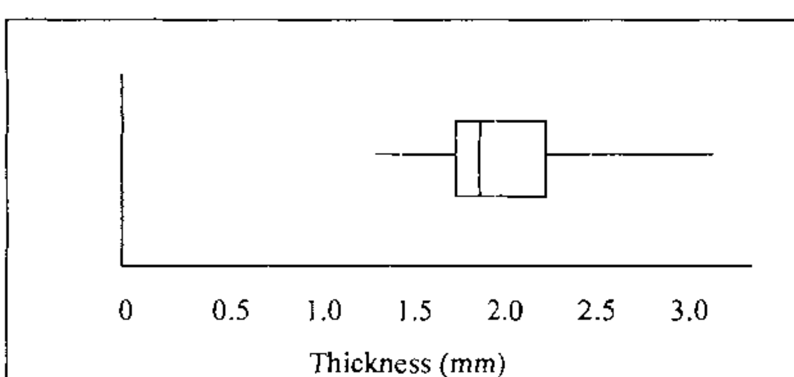


Figure 6-10: Box and Whisker plot showing spread of PNC7 thickness.

The estimated average thickness was found to be 1.982mm. Hence, using the regression equation Y = 0.0081 * X + 540, it can be assumed that conversion factor used for all PNC7 package would be 557grams/m^2.

6.3.7.1. PNC7A Whole Corrugated Boxes

PNC7A is complete box and by estimating the weight of the box was found by calculating the surface area of the box and multiplying it by the conversion factor outlined in the previous section.

For example a box with a surface area of 0.12m^2 would have an estimated weight of 0.120 * 544.55=65grams.

6.3.7.2. PNC7B Corrugated Box with an Open Window

PNC7B was treated as a normal box with on average 6% of the total surface area missing. Hence, estimating the weight of the box with an open window was found by calculating the surface area of the box and multiplying it by firstly the conversion factor then the factor (1-0. 06).

For example a box measuring 0.15m^2 with an open window would have an estimated weight of 0.15 * 544.55 * (1-. 06)= 77.3 grams.

6.3.7.3. PNC7BP Corrugated Box with a Plastic Covered Window

PNC7BP was regarded as any corrugated box with a plastic window. PNC7BP packages were found to have larger windows. The average window size was estimated to be 10%.

For the calculation of the weight of PNC7BP packages there had to be the consideration of the plastic component of the package. Firstly the corrugated board part of the package was estimate by multiplying the conversion factor by the area and then by the factor (1-.0.10). The second stage was to multiply the plastic conversion factor of PNC1C which was 286.74 by the area and then by the 0.10 to estimate the weight of the plastic window.

For example a box measuring $1m^2$ would have an estimated package weight of [544.55 * 1 * (1-0.1032)] + [286.74 * 0.1062 * 1] = 517.17 grams.

6.3.7.4. Data Comparison

This data once compare to real data showed a small variation but was well within the error rate desired. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.8. PNC8 Solid Fibreboard Packaging

PNC8 is similar to PNC7 in terms of the way in which the packages are labelled. The only real difference is that PNC8 is solid fibreboard where PNC7 are corrugated boards.

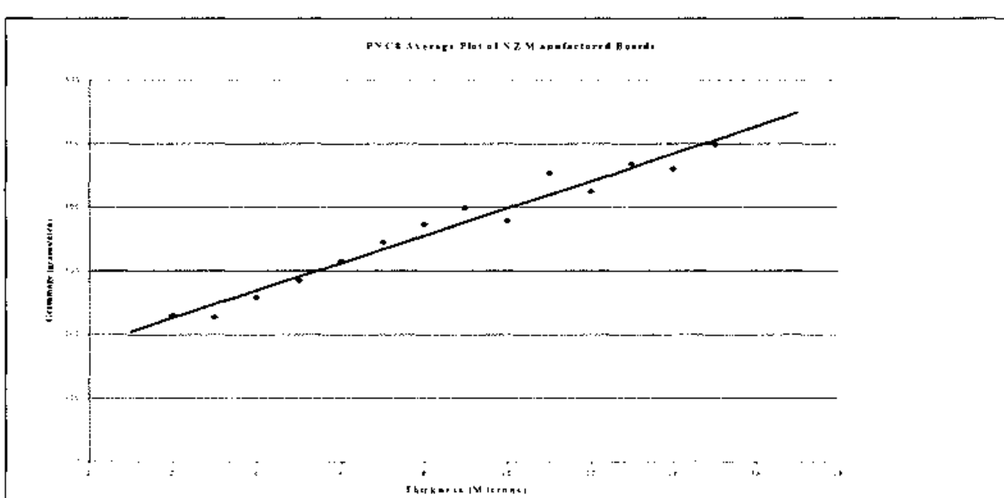


Figure 6-11: Average plot for New Zealand Solid Fibreboard's.

The relationship between the thickness of the boards and the grammage is linear with a correlation coefficient 0.9631. Thus, the regression equation Y =21.49 * X +183.25 was used for further estimates.

From the data collected it was found that 0.78mm was the average for all the boards measured. Hence the conversion factor that was used for all PNC8 data was 0.78mm which when substituted into y = 21.49 * X + 183.25= 200grams.

6.3.8.1. PNC8A Solid Fibreboard Box

Similar to PNC7A, PNC8A is estimated by multiplying the conversion factor by the measured area of each of the packages analysed.

6.3.8.2. PNC8B Solid Fibreboard Box with an Open Window

PNC8B is estimated by multiplying the area of the box with the conversion factor. After completing the data collection the estimated average of the window size was 15.68% of the total surface area. Thus, the last factor in the calculation is (1–0.1568). The total calculation is area * conversion factor * proportion of area of board.

For example a box with a surface area 2.1m^2 would have an estimated package weight of 200. * 2.1 * (1-0.15)= 354 grams.

6.3.8.3. PNC8BP Solid Fibreboard Box with a Plastic Window

PNC8BP is estimated by multiplying the area of the box by the conversion factor and then by the proportion of the area of board. As with PNC7BP, PNC8BP has the addition of the plastic component which is derived by the plastic conversion factor 286 multiplied by the proportion of the total area that is plastic.

The proportion of the area missing due to the window was averaged from the data collected in the stores. The proportion was estimated to be 14.19%. Hence the total area of cardboard is represented by the factor (1-0.1419) and the area value 0.1419 is the area of the plastic.

For example a box measuring $1.75m^2$ would have an estimated package weight of [200 * 1.75 * (1-0.14)] + [1.75 * 0.1419 * 286][5]. This value is calculated to be 371 grams. This value is made up from 300 grams of solid fibreboard and 71 grams of plastic. When listed in the final spreadsheet both the total weight and the separated weight is listed.

6.3.8.4. Data Comparison

This data once compare to real data showed a small variation but was well within the error rate desired. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.9. PNC9 Common SFB and Plastic Combination Packages

For each newly defined nominal group data was collected and then arranged into interval groups based on their size. For example 9C2 packages was derived as any similar type package that has solid fibreboard with an area between 13000 and $36000mm^2$. These packages were categorised by the size of the SFB component of the package.

2. [5] The areas for all the PNC8 and PNC7 sub clusters example calculations are made up to illustrate example calculations. The remaining factors in all the calculations are true values that are used in the calculation of the total volume of retail packaging.

6.3.9.1. PNC9AX SFB Tag with Plastic Bag.

After collecting data on these packages the following information was attained under the following considerations:

Each package has two sides to the SFB component of the package.
Each package has two sides to the plastic component of the package

9AX No.	Ave SFB Area m^2	AVE SFB Thickness mm	Ave Plas Area m^2
1	0.003300	1.1	0.005
2	0.008344	1.1	0.033
3	0.034500	1.1	0.110
4	0.056400	1.1	0.211
5	0.061550	1.1	0.256

Table 6-2: Measured data from PNC9AX samples.

From this data and the conversion equations for plastic and SFB that were derived in this chapter the estimated weight of each of the packages was made. There was however other considerations that needed to be made.

The conversion equation for the SFB component of the package is Y = 21.49 * X +183.25. Using the average thickness for this particular package completed this equation. The conversion factor for the plastic component of the package is PNC1A, which was 95.58gsm. (Table 6-6)

After considering these assumptions the following sample calculation could be made.

Components	Conversion	Total
SFB = 0.003300	[21.49 * 1.1 + 183.25] * 0.0033	0.68grams
Plastic = 0.00440	0.0088 * 95.58	0.84grams
Total Package Weight	Conversion 1 + Conversion 2	1.52grams

Table 6-3: PNC9A1 sample calculation.

These calculations were repeated for each of the five sectors of PNC9AX. Table 6-4 below shows the estimated SFB and plastic weights for each of the sectors.

9AX No.	SFB Weight (g)	Plastic Weight (g)	Total Package weight (g)
1	0.682	0.841	1.52
2	1.726	3.064	14.79
3	7.350	11.04	18.37
4	11.67	20.16	31.84
5	12.73	24.50	37.24

Table 6-4: Calculated package weights for PNC9AX packages.

6.3.9.2. PNC9CX SFB Backing with Plastic Front

From the data collected in the stores the following information was found considering the following factors. Each package has a SFB back that provides the package with protection and a place for the product to be hung from. Each package has a plastic front that holds the product in and onto the SFB backing.

9CX No.	Ave SFB Area m^2	AVE SFB Thickness mm	Ave Plas Area m^2
1	0.01	0.56	0.0049
2	0.02	0.94	0.0101
3	0.05	1.07	0.0278
4	0.08	1.18	0.0590
5	0.11	1.30	0.0841
6	0.13	1.39	0.1105
7	0.36	1.50	0.2728

Table 6-5 measured data from PNC9CX samples

Using this data and the conversion equations that were derived for plastic and SFB in this chapter the estimated weight of each of the packages was made. However, other considerations needed to be made.

The conversion equation for the SFB component of the package is Y = 21.49 * X +183. Using the average thickness for this particular package completed this equation. The conversion factor for the plastic component of the package is 286.74gsm. After considering these assumptions the following sample calculation could be made.

Components	**Conversion**	**Total**
SFB = 0.0092	[21.49 * 0.566 + 183] * 0.0092	1.81grams
Plastic = 0.0049	0.004 * 286.74	1.41grams
Total Package Weight	Conversion 1 + Conversion 2	3.22grams

Table 6-6: PNC9C1 sample calculation.

These calculations were repeated for each of the remaining 6 sectors of PNC9CX. Table 6-7 below shows the estimated SFB and plastic weights for each of the sectors.

9CX No.	**SFB Weight (g)**	**Plastic Weight (g)**	**Total Package weight (g)**
1	1.810	1.417	3.23
2	4.896	1.741	6.64
3	12.00	7.989	20.00
4	17.53	16.93	34.46
5	24.84	24.13	48.97
6	28.53	31.69	60.22
7	77.89	78.22	156.1

Table 6-7: Calculated package weights for PNC9CX packages.

6.3.9.3. PNC9EX Plastic Snap Together Packages with SFB Tag Inside.

From the data collected in the stores the following information was found considering the following factors.

- Each product has a double-sided plastic package that snaps together holding in the product. Thus calculations will need to be twice the area in order to cater for the two sides of plastic.
- Each package has a SFB tag that is placed inside the package but is obvious to the consumer.

The data shown in the Table 6-8 shows the information that was measured through the sampling process in the Warehouse.

PNC9EX No.	**Ave Plastic Area (m^2)**	**Ave Tag Weight (g)**
1	0.021	3.75
2	0.117	6.40
3	0.158	7.25
4	0.480	8.20

Table 6-8: Measured data from PNC9EX samples.

Using this data, calculations could be made to estimate the package weight of the PNC9EX packages. The following considerations were to be made in order for the weights to be calculated

- The conversion of the average of plastic into a weight would be done using the equation Y = 2 * [286.74 * Area].
- The SFB tag was measured using weight not a conversion from area to weight.

After considering these factors the following calculations were made in order to estimate the total package weight.

Components	Conversion	Total
SFB	N/A	3.75grams
Plastic = 0.02310 (both sides included)	[0.23 * 286]	6.11grams
Total Package Weight	Conversion 1 + Conversion 2	9.86grams

Table 6-9: PNC9EX sample calculation

Using the sample calculation shown in Table 6-9 the following estimated weights were derived for each of the four categories within PNC9EX.

9EX No.	SFB Weight (g)	Plastic Weight (g)	Total Package weight (g)
1	3.70	6.11	9.86
2	6.40	33.65	40.00
3	7.20	45.40	52.68
4	8.20	137.60	145.80

Table 6-10: Calculated package weights for PNC9EX packages.

6.3.9.4. Data Comparison

This data was measured at the store while the trials were taking place. The results of the SFB and plastic estimations were derived from other areas of this study, hence no comparison was undertaken. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.10. PNC10 Glass Bottles

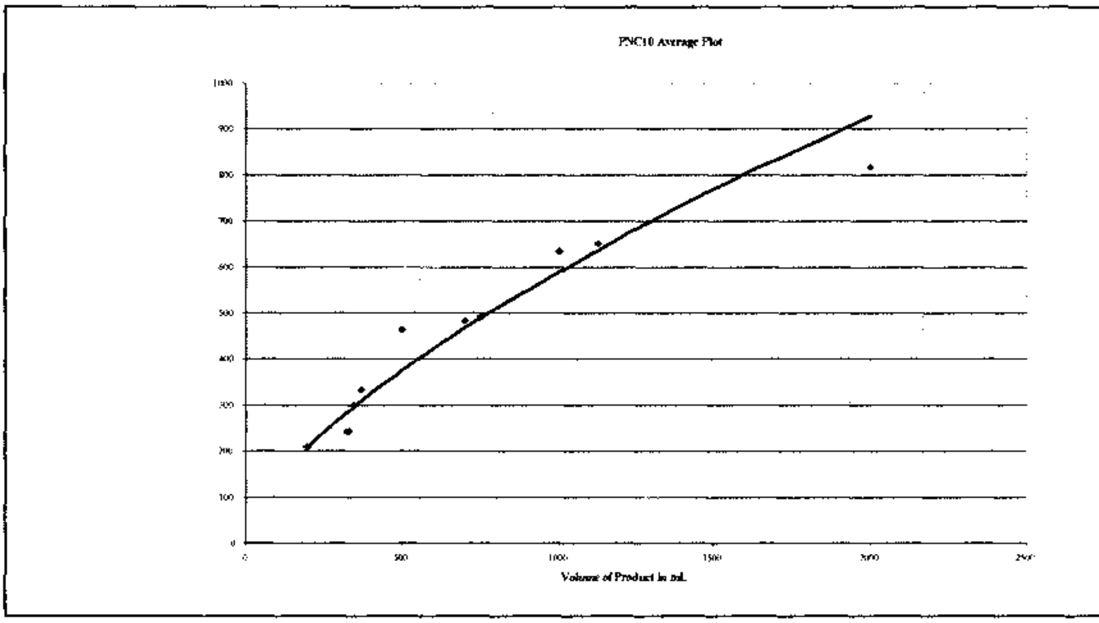


Figure 6-12: PNC10 conversion equation graph

The plot between the measured data from the sampling process and the volume of the package shows a good fit, this is reinforced by the fact that the correlation coefficient is 0.9374.

Glass package weights were estimated using Y = 6.4713 * X ^ 0.6532.

6.3.10.1. Data Comparison

This data comparison highlighted a very important point. Although packages carry the same volume the structure of the package and thickness may not be the same. Therefore the difference between 2 identically sized bottles may be greater than that calculated by the conversion equation. The errors therefore are larger but in the opposite direction to each other. This was very evident with 750ml bottle of which there were a large number. Of the bottles measured the average of these was 5.2% lower than the value calculated by the conversion equation. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.11. PNC11 Glass Jar Packaging

PNC11 was divided into two different conversion equations, one for products labelled in volume and the other for products labelled in net weight. The difference between the two sets of data is shown in Figure 6-13.

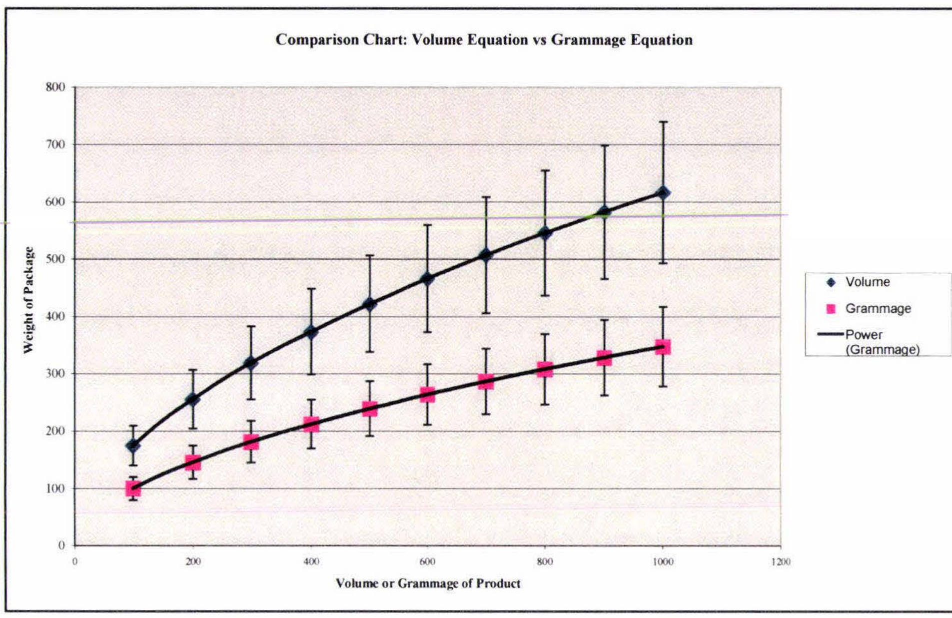


Figure 6-13: Comparison chart for PNC11 volumetric and gross weight data.

Figure 6-13 shows that there is significance difference between the measured samples of the volume labelled data and the net weight labelled data. The two functions on the graph do not overlap even with error bars in the Y direction of 20%. Thus PNC11 will be treated as two very separate conversion equations.

6.3.11.1. Glass Jars Labelled with Volume

The regression analysis of this data shows that there is a strong relationship between the volume of the product and the weight of the package with a correlation coefficient of 0.9745. Therefore, conversion equation $Y = 14.018 * X ^{0.5478}$ was used to estimate the package weights.

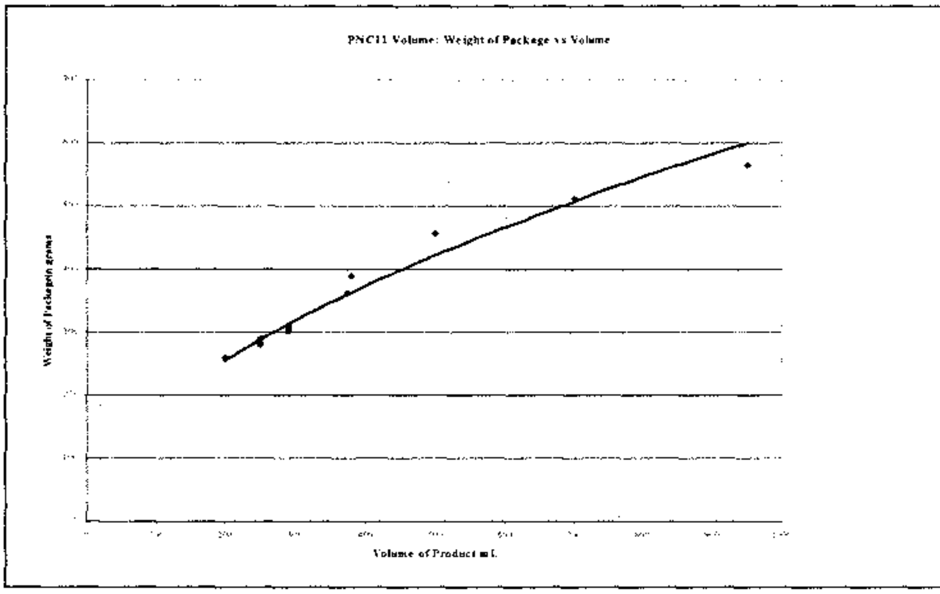


Figure 6-14: PNC11 Volume: conversion equation graph

6.3.11.2. PNC11 Net Weight Labelled Jars

Regression analysis plot for PNC11 net weight. This plot shows strong a strong relationship between package weight and the net weight of the product with a

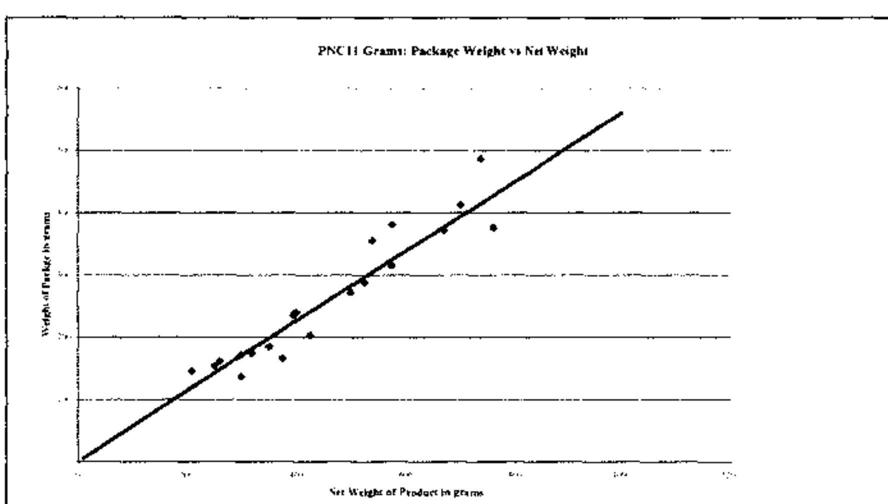


Figure 6-15: PNC11 Net Weight conversion equation graph.

correlation coefficient of 0.9014. The correlation coefficient is well within the expectations discussed at the start of this chapter. Therefore the resulting regression equation of $Y = 0.6135 * X ^ {0.9868}$ was used to estimate the package weight of these packages.

6.3.11.3. Data Comparison

In both sets of data there is evidence overfilling. However with this in mind the error rate is still accurate enough to be considered a good fit. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.12. PNC12 Tin Can Packaging

Tin cans are very structured and their package weights do not vary a great deal. This is reinforced the correlation coefficient is 0.9203.

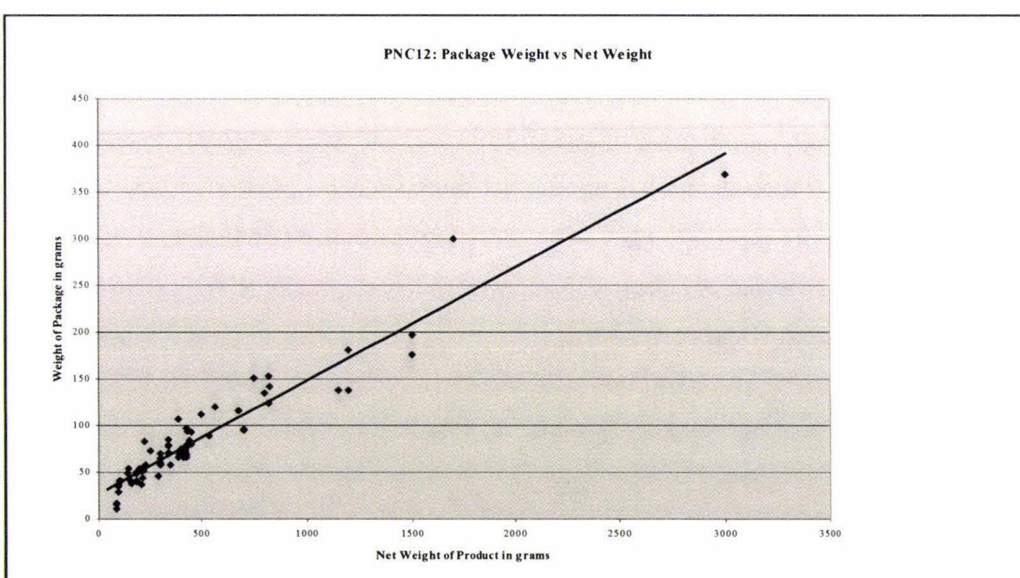


Figure 6-16: PNC12 Conversion equation graph.

The estimation of PNC12 packages was calculated by $Y = 0.1216 * X + 26.199$.

6.3.12.1. Data Comparison

Variation in the estimations was due to varying packaging. Some more industrious packages were more robust in structure to the food cans. The errors were skew because of this however there was still a close between the estimated weight (Net gross weighing method) and the actual weight. This data was also hindered in the food sector by overfilling. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.13. PNC13 Tin Tubes Packaging

After collecting the data it was discovered that PNC13 was smaller in terms of samples than first predicted. Hence, using an average value to estimate the package weight instead deriving a regression equation was used. The average value for PNC13 was found to be 26 grams.

6.3.14. PNC14 Sachets and Laminated Packages

An average package weight was measured in PNC14 similar to how it was in PNC13. However the difference in this case was that there were a lot of samples throughout the range of products but there was a limited variety in terms of the package weights. The range of values measured empty packages was spread from 8 grams through to 14 grams hence an average value of 11 grams.

6.3.15. PNC15 Foil Packaging

Similar to both PNC13 and PNC14, PNC15 is estimated by an average value. The packages were generally small the spread of the measured data was small enough to assume that an average was a fair representation of the products package weight. PNC15 is represented by the average value 13.

6.3.16. PNC16 Other or Non-Recognisable Packages

This nominal code was defined as packages that were non-recognisable by staff collecting the data. Hence there is no equation or conversion value.

6.3.17. PNC17 Aerosol Packaging

PNC17 used a linear function to represent its data. This proved to be more accurate than using either a power or a logarithmic relationship. The actual regression line has a correlation coefficient of 0.9148, which would mean that there is strength in the relationship. The resulting regression equation of Y = 0.2565 * X +13.66.

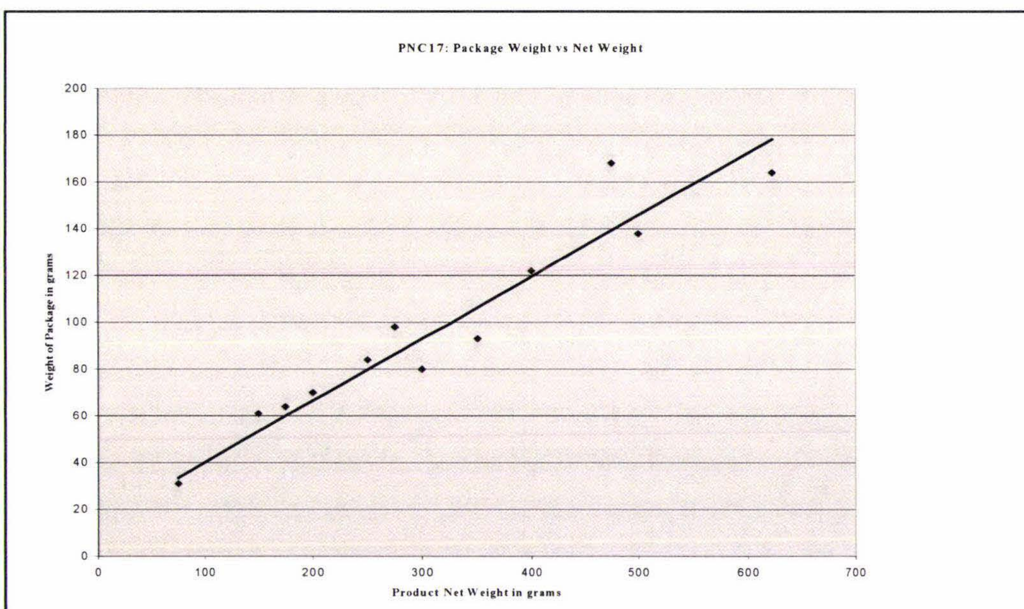


Figure 6-17: PNC17 conversion equation graph.

6.3.17.1. Data Comparison

Aerosols have a huge variation. The actual data vs the estimated stacked up not to bad. However this was only bought about by the large and indifferent errors being summed and divided to give a good result. (Refer to Estimated vs Real Package Weight on the appendix CD)

6.3.18. PNC18, PNC19, PNC20, PNC21 Bottle Store Nominal Codes.

These nominal codes are identification codes only. Their estimated package weights are made of those factors that have been derived. For example PNC19 is a combination of glass bottles and SFB.

6.3.19. PNC22 Aluminium Can Packaging

Aluminium cans are commonly used for beverage containment. From the data that was collected it was obvious that aluminium cans only come in a small number of sizes. Unlike other products where the grammage of products may spread from 50grams through to 20kg PNC22 has a spread that stretches from 250ml through to 500ml. The majority of the packages in PNC22 are based around the 300 to 355ml range. Table 6-11 below shows the limited range of cans and their measured weights.

Can Size (Volumetric Value, mL)	Measured Package Weight
250	27.50
300	29.00
330	30.00
355	30.80
375	31.40
440	33.50
500	35.40

Table 6-11: Table of PNC22 can size and package weight.

6.4. Outcome

The outcome of this chapter is the regression equations and the conversion rates of each of the 22 packaging nominal codes. The table below shows the code and the primary equation or value that will used to amass the totals of each form of packaging material, totals from the stores as individual entities and the total of all the stores.

6.4.1. Plastic Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
1	0.4741 * X ^ 0.6966	N/A	N/A
1A	N/A	191.16 * Area	N/A
1B	N/A	382.82 * Area	N/A
1C	N/A	573.48 *Area	N/A
2	0.9596 * X ^ 0.5823	N/A	N/A
3	N/A	N/A	36.5 grams
4 Volume	2.1278 * X ^ 0.5483	N/A	N/A

Table 6-12: Plastic packages outcomes.

Equation converter: X = volume or weight (mLs or grams)

6.4.2. Paper Lamination Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
5	0.0454 * X + 11.741	N/A	N/A
6	16.787 e ^ 0.0016 * X	N/A	N/A

Table 6-13: Paper lamination package outcomes.

Equation converter: X = volume or weight (mLs or grams)

6.4.3. Paperboard Package

PNC	SFB Converter	Plastic Converter
7A	[0.0081 * X + 540] * Area	N/A
7B	[0.0081 * X + 540] *Area * (1-0.05)	N/A
7BP	[0.0081 * X + 540] *Area * (1-0.10)	Area * 0.1062 * 286
8A	[21.49 * X +183] * Area	N/A

8B	[21.49 * X +183] * Area * (1-0.15)	N/A
8BP	[21.49 * X +183] * Area * (1-0.14)	Area * 0.1419 * 286

Table 6-14: Paperboard package outcomes.

SFB converter: X = Thickness

6.4.4. SFB and Plastic Combination Packages

PNC	SFB Converter	Plastic Converter
9AX	[21.49 * X + 183] * Area	95 * Area * 2
9CX	[21.49 * X + 183] * Area	286 * Area
9EX	[21.49 * X + 183] * Area	286 * Area * 2

Table 6-15: SFB and plastic combination outcomes

SFB converter: X = Thickness

6.4.5. Glass Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
10	6.47 * X ^ 0.65	N/A	N/A
11 Volume	14.0 * X ^0.54	N/A	N/A
11 Grammage	0.61 * X ^ 0.98	N/A	N/A

Table 6-16: Glass package outcomes.

Equation converter: X = volume or weight (mLs or grams)

6.4.6. Tin Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
12	0.12 * X + 26.1	N/A	N/A
13	N/A	N/A	26 grams

Table 6-17: Tin package outcomes

Equation converter: X = volume or weight (mLs or grams)

6.4.7. Foil Lamination Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
14	N/A	N/A	11.1 grams
15	N/A	N/A	12.9 grams

Table 6-18: Foil lamination outcomes.

Equation converter: X = volume or weight (mLs or grams)

6.4.8. Steel and Metal Packages

PNC	Equation Converter	Conversion Factor	Average Estimate
17	Y = 0.2565 * X +13.66	N/A	N/A
22	0.0315 * X + 19.63	N/A	N/A

Table 6-19: Steel and metal package outcomes.

Equation converter: X = volume or weight (mLs or grams)

6.5. Summary

This chapter outlined the methodology behind deriving the conversion factors and the conversion equations in order to calculate and estimate the total package weights within the retail sector.

This chapter followed a simple methodology and simple statistics in order to make these derivatives. The use of linear, polynomial, power and exponential functions further reinforced the relations that were already apparent from the data collection. At the start of the chapter assumptions were made in order for the conversion rates and the equations to have a certain level of accuracy. Recalling those assumptions, 0.7 to 0.8 correlation coefficient factor would be assumed a fair fit whilst a correlation coefficient of 0.8 to 1.0 would be considered a good fit for this project.

A manual with all the data and explanation of all the PNC and the equations is provided on the appendix CD under file "Conversion Equation Manual".

Chapter 7. Secondary Packaging Analysis

7.1. Aim

To design and develop and methodology for analysing and calculating the volume of secondary packaging.[6]

7.2. Methodology

The methodology of this chapter follows the flow chart shown below in Figure 7-1.

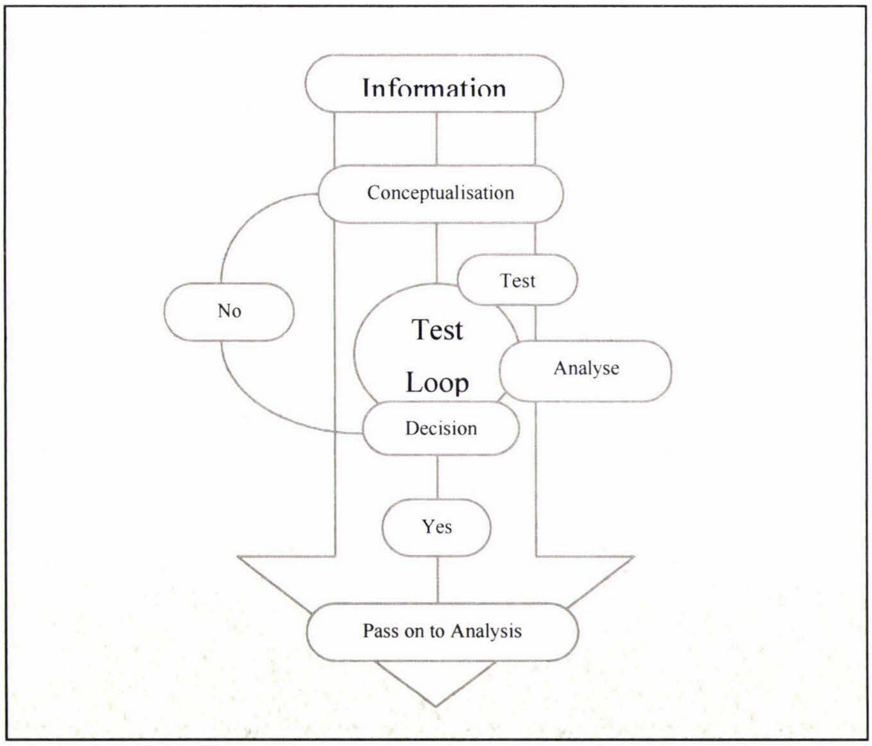


Figure 7-1: Flow chart of the secondary packaging analysis chapter

[6] Secondary Packaging in this project refers to the paperboard boxes used to transport product on pallets. All secondary packaging in this project is not shelf and customer bound.

7.3. Results

7.3.1. Information Needs

What information was required in order to make an estimate on the total secondary packaging that is used?

The information needs were dependent on the process that was designed and developed in this section of work.

The main information needed is how much corrugated card or PNC7 is used is the transportation of products from manufacturer to store? After reviewing the pallets and containers of products that arrive at the four stores it was discovered that 95% of the products are encased in corrugated board through transportation. Thus, the total estimate of the secondary packaging used can be assumed to be the sum of the weights of the disposed board at the four stores.

7.3.2. Secondary Packaging Analysis Process Design

After using simple ideation/brainstorming techniques three designs for calculating the secondary packaging were generated. Considering the data requirement and the difficulty of obtaining this data these designs are very crude.

7.3.2.1. Design One: Store or Warehouse Evaluation

This methodology consisted of, going into the warehouses or storerooms of the stores and measuring the areas and the thickness' of the boxes that the products arrived in. Using this information in conjunction with conversion factors previously designed the total estimate for the weight of the secondary packaging would be found.

7.3.2.2. Design 2: Pallet Analysis

The second design consists of analysing the pallets that arrive into the stores for one week. Estimate the total number of boxes and measure these to obtain the information, then using conversions factors estimate the total weight of secondary packaging on one pallet. This then can be repeated on all the pallets that arrive into the store in that week. Then average those weights that are estimated and extrapolate into year's worth of pallets.

7.3.2.3. Design 3: Recycling Analysis

The third design consists of analysing the recycling that the four stores participate in. Pak N Save and Woolworths compress and strap up their loose paperboard from in the storerooms into cubes for recycling. This design would consist gaining information pertaining to the total average weight of one cube. The second piece of information is how many cubes are disposed of in one week for the stores. Because these two stores are the only stores that complete this procedure, assumptions would need to be made in order for this design to work with other stores.

7.3.3. Concept Testing

7.3.3.1. Concept Testing Time Analysis

The testing of these concepts consisted of a time measurement. Each method was tested from start to finish at The Warehouse. Table 7-1 below shows the results from the tests in terms of time.

Design Name	Total Weight (T)	Total Time to Complete Test
Storeroom analysis	10228	3 weeks 4 days
Pallet Analysis	9017.5	2 weeks
Recycling Analysis	10027	0.5 day

Table 7-1: Table of test times for secondary packaging designs.

7.3.3.2. Results Explanations

7.3.3.2.1. Design One: Store or Warehouse Evaluation

This method failed miserably because of the time and resource efficiency factor. Measuring every box that comes into the store and then calculating the necessary information would be a long-winded and drawn out process.

The actual output of this process may be quite accurate. Table 7-2 shows the results and the data that was obtained from the test.

Woolworths	Week Starting	28/05/2001
Pallets Tested	57	69
Total Number of Boxes	3420	4278
Average Weight of Box	500 g	500 g
Total Weight of Week in Kg	1710	2139
Total Weight of One Pallet	29.86	31.00
Total Estimate Number of Pallets Nationally	336161	336161
Total Weight Tonnes	10037	10420

Table 7-2: Design One: Individual Box Analysis.

7.3.3.3. Design 2: Pallet Analysis

This proved to be a very good method in terms of its time usage however it has one major pitfall. Each pallet that arrives in at the store is so very different to one that proceeded it; therefore taking the average is a very crude method. The results below show why this method is deemed to be erude.

Woolworths	Week Starting 05/05/01	Week Starting 12/05/01
Pallets Tested in Week	59	61
Average Number of Boxes	51	38
Average Weight of Pallet	21.036 kg	31.814 kg
Total Estimate Number of Pallets Nationally	336161	336161
Total Weight Tonnes	7071	10964

Table 7-3: Results of Design 2: Pallet Assessment

From Table 7-3 it can be seen that this methodology has a huge variation. In the two weeks that it was trialled there was a 44% difference in the 2 pallets. If an average was going to be estimated based on the assumption that all the pallets vary by that much, then the final result will not be as accurate as first hoped.

This accuracy issue in combination with the time scale that this design entails means that this design methodology would not be considered.

7.3.3.4. Design 3: Recycling Analysis

This method proved more successful than first thought. In making contact with Pak N Save and Woolworths the correct information was able to be passed across, eliminating any contact time with stores and the pallets.

For example, Woolworths provided the following information

- On average 64 pallets enter the store each week.
- 21 cubes of board are sent out each week
- On average there are 11 cubes to the tonne (Information supplied by Woolworths Palmerston North)
- Palmerston North branch makes up 0.99% of the total national sales volume.
- The Warehouse does not use the compaction and recycling method to eliminate waste. For this methodology to be applied to The Warehouse the information pertaining to the quantity of shippers would need to be supplied. Then, assuming that The Warehouse did compact and recycle their secondary packaging estimation based on the calculations above could be made. This is the only conceivable methodology to estimate the secondary packaging waste form The Warehouse.

From this point the following calculation were able to be made:

Calculation 1: 64 *52 = 3328 this is the total number of pallets entering this store in 1 year.

Calculation 2: (100/0.99) * 3328 = 336161 this is the total number of pallets that are used by all the Woolworths Stores in this country.

Calculation 3: 336161 * (21/64) = 110302 this the total number of cubes that are disposed of. The factor (21/64) is the disposing factor this explains that of every 64 pallets that arrive in the store 21 cubes are made and sent from the store.

Calculation 4: 110302/11 = 10027 this calculation represents the total weight of secondary card in tonnes. Because there are 11 to the tonne then the total number of cubes divided by 11 must equal the total weight.

Design one and design three had very similar results. However the time frames in which they were completed were very different. Design two on the other hand was moderate in terms of time use but the results of secondary package weight are variable and differ by up to 40% from the other two methods.

From this point it can be said that design three is the most likely choice when completing the total analysis for all the stores and all the data.

7.3.4. Outcome

The outcome of this chapter is that Design 3 which looks at the assessment of the recycling of the stores will be used in the final analysis. The process of this methodology is very simple providing the correct information is provided. Once the information is provided then the steps involved to arrive at a solution is very simple. Figure 7-2 shows the complete process used to assess the total weight of secondary packaging in The Warehouse, Pak N Save and Woolworths. Liquor King will not be assessed in this manner because the product is shelved in its secondary packaging. Therefore it will be assessed in store. Because of the small number of products stocked in Liquor King each product and its secondary package will be assessed using the methodology in Design 1.

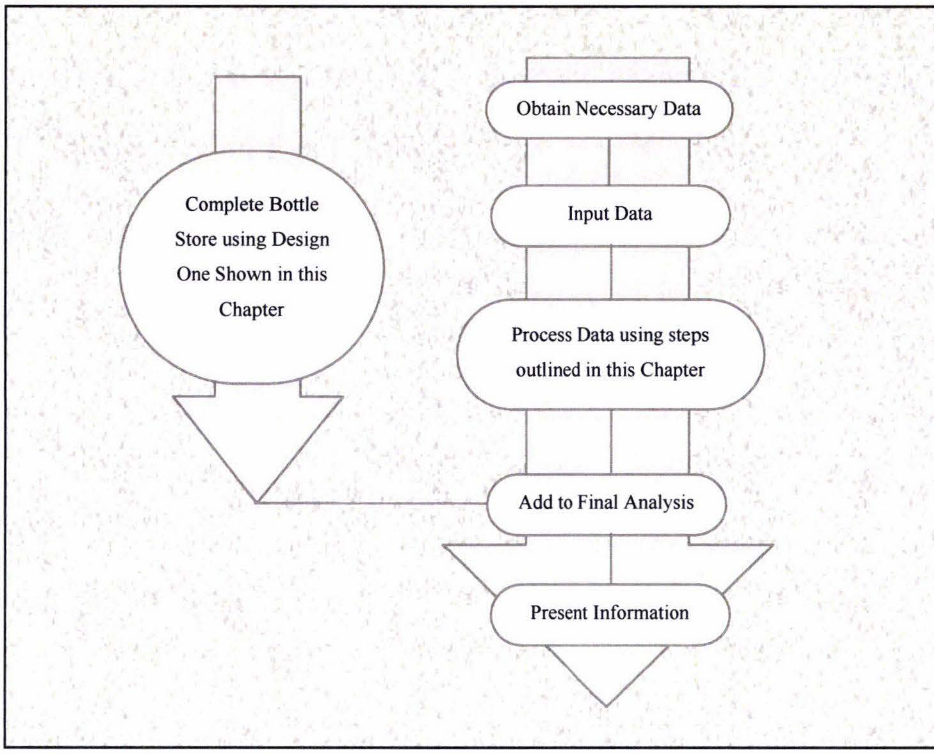


Figure 7-2: Process Flow Diagram for Pallet and Secondary Packaging Analysis

7.3.5. Summary

This chapter reviewed the part that secondary packaging plays in terms of the total weight of retail packaging. This chapter also looked at the design and testing of three separate methodologies to assess and calculate the total weight of the secondary packaging.

The tests performed assessed the time taken to complete the process and the results that they each produced. The times taken to assess the pallets and secondary packaging varied considerably Design 1 was very extensive in terms of labour and time consumption while Design 3 took one person less than half a day. However their final total estimated weights were very similar. Design 2 however was moderately time and labour extensive yet the results of the weight were quite variable.

From the results of the tests Design 3 looked as if it would supply the correct information in the smallest amount of time consuming the least amount of resources. Therefore, Design 3 will have its results in the final analysis.

Chapter 8. Data Analysis

8.1. Aim

The aim of this chapter was to bring together all the information and data and process it so that the main objectives of the project are answered.

8.2. Methodology

The methodology of this chapter was not pre determined. As this is the first year in which this process has been run it was hard to pin point the exact tasks that were going to be undertaken.

With clear objectives and aims set out in the introduction of the thesis, it was a job of working toward answering and satisfying those aims and objectives. Once the procedure had finished then document the procedures in the procedure manual and present the findings for this year.

The first was to obtain the relevant sales data. In previous years each of the stores gave the project sales data similar to the format of the stocklist printout. However a better source of information was found. AC Neilson was able to provide the project with comprehensive grocery sales data. This incorporated all the grocery stores and outlets in the country. This in turn would provide more realistic results. The Warehouse and Liquor King also provided national sales, which was used in the data analysis.

The next stage was to calculate all the package weights for all the products in the project. This was complete through the use of conversion equations and conversion rates outlined in Chapter 6 of this thesis.

Once this was completed the relevant sales data could then be added to the spreadsheet and multiplied by the estimated package weight. The result of this calculation would be a total estimate of the weight of waste packaging produced by that product in the year that, that sales data was taken from.

Product Name	Estimated Weight	Sales Data (units)	Total Weight (T)
Red Wine 750ml	500g	10000	5
Biscuits 250g	42.5g	124587	5.3
Golden Syrup 500g	125g	4015289	501.8

Table 8-1: Sample data to show methodology of data analysis

Using Microsoft Excel this information could be calculated and then transposed into a presentable sheet. This sheet could then have descriptive statistics techniques generated from that.

The file was generated and saved as one completed file with different worksheet names.

8.3. Assumptions

AC Neilson's Grocery Sales Statistics used in the calculations represent 80% of the total grocery market in New Zealand. (AC Neilson, 2001)

8.4. Results

The results were divided into sections as per the requirements of the objectives in Chapter One of this thesis. Analysis of the total volume of retail packaging; the proportion of imported to NZ made packages and finally the material make up of the total.

8.4.1. Total Volume of Retail Packaging

The total volume of retail packaging generated by All Grocery Stores, the Warehouse and Liquor King is shown in Table 8-2.

Retail Sector	Grocery #	General Merchant.	Liquor Wholesale	Totals
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Product Packaging	182576	96161	• 40078	318815
Shippers	88464	92907	*	181371
% Imported	19	81	40	44%
Tonnes imported	51498	153145	16031	220674
% Local	81	19	60	56%
Tonnes local	219542	35923	24046	279512
Totals	271040	189068	40078	500186

Table 8-2: Total Volume of New Zealand Retail Packaging.

AC Neilson

* Shipper Information included in product packaging data, not treated separately as the other stores were

This total included the primary packaging and the secondary packaging that was determined through the pallet assessment.

8.4.2. Proportion of New Zealand made Packaging to Imported Packaging

The total weight of retail packaging was split into what packaging was made in New Zealand and that what was imported into the country. This was regulated by what country the label of the product says it was made in.

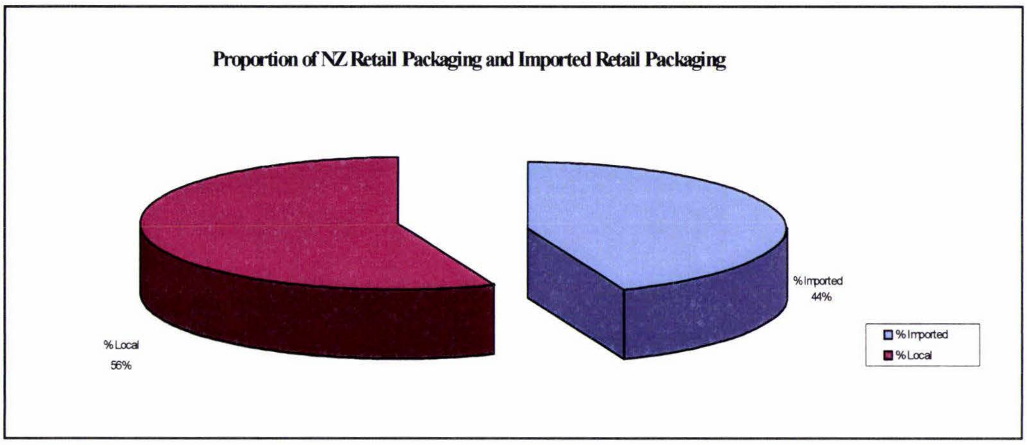


Figure 8-1: Graph of NZ vs Imported Packaging by Volume

8.4.3. Packaging Sector Breakdown

The packaging sector breakdown is the percentage of the total weight that each broad category represents. Some of the nominal codes represent more than one type of packaging. For example 9C2 has both SFB and plastic, for this analysis, the materials were separated and added to the appropriate sector.

All nominal codes were gathered into their respective packaging origins. For example PNC1, PNC2, PN4, the plastic component of 9AX, 9CX and 9EX are grouped to represent all the plastic products. Table 8-3 gives an indication of the volumes that each of the packaging materials generates in one year. On the right hand side column is the estimated tonnage that was given to the packaging council by the governing bodies of the respective packaging boards.

Materials	Packaging Ex Retail (tonnes)	2000 Mass Balance Consumption data (tonnes)
Aluminium	1750	6965
Glass	75995	120810
Paper	280953	308770
Plastics	116907	117475
Steel	23963	28385
Total	500186	582406

Table 8-3 Total Volumes generated by each package type.

8.5. Summary

This chapter reviews the analysis of all 67000 pieces of data. This chapter firstly looks at the brief methodology involved and then the results that were derived from it. This chapter then looks at the breakdown of the results as per the objectives first expressed in Chapter 1. These main outcomes are as following:

- The total weight of Retail Packaging generated by all grocery stores, The Warehouse and Liquor King was 500186 tonne.
- The total volume of New Zealand made packaging was 279511 tonne which corresponds to 56%
- The total imported volume of packaging was 220674 tonne which corresponds to 19%
- Paper held the largest proportion of volume at 56.17%, while plastics represented 23.37%.
- Glass and Steel were the last big occupiers of volume with 15.19% and 4.8% respectively.

The complete set of data and analysis is provided on the Appendix CD under the file PCNZ Data Aug 2002.

Chapter 9. Development of Procedures Manual

9.1. Aim

The aim of this chapter was to develop a procedure manual for the project. The procedure manual should outline the following factors:

- The procedure for collecting nominal data.
- The procedure for measuring each product to obtain its measurement data.
- Outline the project and its origin and meaning.
- The manual should outline the future plans of the project.

9.2. Methodology

The methodology of this section of work followed the flow chart shown in Figure 9-1.

Designing a procedure manual first requires the project leaders to investigate methods that were undertaken in the actual data collection process of the project. Then using this process, consider the following questions:

- Can this be written in Laymen's terms?
- Is the process logical?
- Does the process allow any room for error?

Once the process satisfies these criteria then it can be designed and written in procedure from for the next stage.

The next stage of the methodology followed a simple write design-test-loop that was derived to eradicate any problems that were foreseen in the future. If the procedure list designed is able to satisfy the tests then that procedure list will be accepted. The test involved having 3 independent members read and trial the test for ten different products made from ten different materials or from ten different nominal groups.

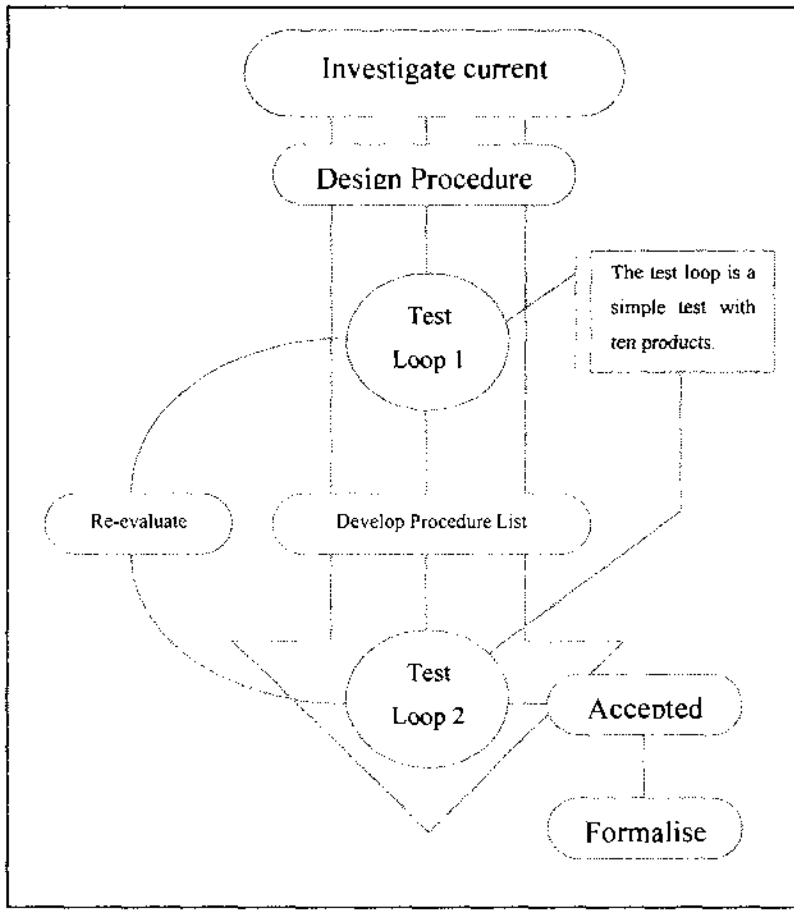


Figure 9-1: Methodology for preparing Procedures Manual

Once formal acceptance from client and supervisory staff has been given then the procedure list can formally written and printed into booklet and manual form.

9.3. Results

9.3.1. Investigation into Current Procedure

An investigation into the final procedure designed and developed in chapter five was considered and tested in this section.

The following points were found to be ambiguous and will need further development before they become a part of the procedure manual.

9.3.1.1. Language Barrier

Although the language was not all jargon some of what was developed in the project will need defining or revising for non-trained staff and personnel to understand and use the procedures.

9.3.1.2. Completion of Whole Procedure

The outcome of chapter five was a complete process for the collection of data for this project. However completing this project in the future will require more analysis and collaboration of data. Therefore the procedure manual should outline all the necessary steps in order to complete the project in whole.

9.3.1.3. Projection or Future Plan

After lengthy discussion with previous operators and the client it was decided that the process needed to be developed and extrapolated into a three year plan. This includes what needs to be undertaken in each of the years leading up to the termination of the three year plan.

9.3.1.4. Logical Steps

Although the process appears to be in logical form the procedure list needs to have several more steps to ensure that the process is error free and easy to follow. These include an in-depth description of what the project consists of, the requirements before the project commences and what is required during and at the completion of the project.

9.3.2. Design of Procedure List

After considering the factors outlined in the previous section the procedure list was designed for trial and test use. A brief skeleton of the test procedure is shown below in the Table 9-1.

Section	Title	Subtitle
1	Overview	
1.1		Three Plan and Description
2	Stages to Complete Process	
2.1		Contact Companies for Printouts
2.2		Obtain printouts
2.3		Collect New Data
2.4		Analyse Data
2.5		Present Findings
3	Outline of Conversion Factors	
4	Recommendations	

Table 9-1: Table of Skeleton of Procedure Draft (1st Design)

9.3.3. Test Loop 1

The daft procedure list was examined by supervisory staff for grammatical and spelling errors. These changes were made and the procedure list was then taken into the test involving an independent operator and ten simple grocery items that were commonly found in the stores in operation.

The actual steps of the process were found to be simple and easy to follow. However the descriptions of the steps involved proved to be too brief. The independent operators were able to point out areas that needed revising and reviewing before the next test.

9.3.4. Test Loop 2

The second test loop indicated that there were some issues with the description of the procedures and the equation in the conversion equations sections. The following problems were identified:

- No instruction as to what dimensions needed to be recorded for those nominal codes that required measuring.
- Photos of the type of packages that each nominal code stand for would assist in package identification
- There was a lack of a description of packages and what common examples may be found on the shop shelf.

9.3.5. Development of the Procedure Manual

The advice passed on from the two test loops was used and the following changes were made:

- Some language defined or replaced.
- Computer input aspects needed greater explanation.
- All first person and pronoun use was removed.
- A separate manual was written to explain in depth each packaging nominal code.

These changes were made to the procedure manual and the manual was passed onto the client and supervisory staff for approval before the final manual can be formally written and added to the package.

9.4. Outcome

The outcome of this chapter was two manuals. The first outlined the general procedures including the steps involved in presenting the information. The second was a conversion equations manual which outlined each nominal code, providing photos and descriptions of similar products, description of what measurements are required and a full list of equations and the scatter plots that derived them.

The general procedure flow chart for the first two years of the three-year cycle is shown below in Figure 9-2 while the third year, which requires a reinvestigation of the conversion equations, can be seen in Figure 9-3. The complete manuals can be found on the Appendix CD.

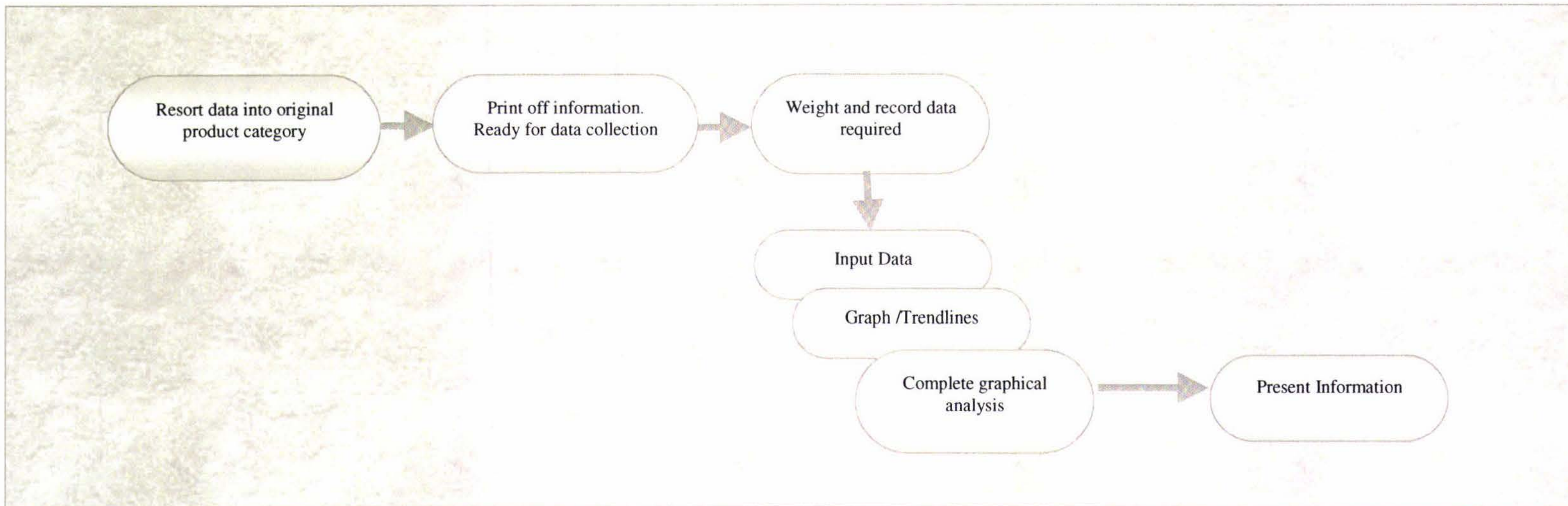


Figure 9-2-: Procedure flow chart for the first and second year of the Packaging Analysis System

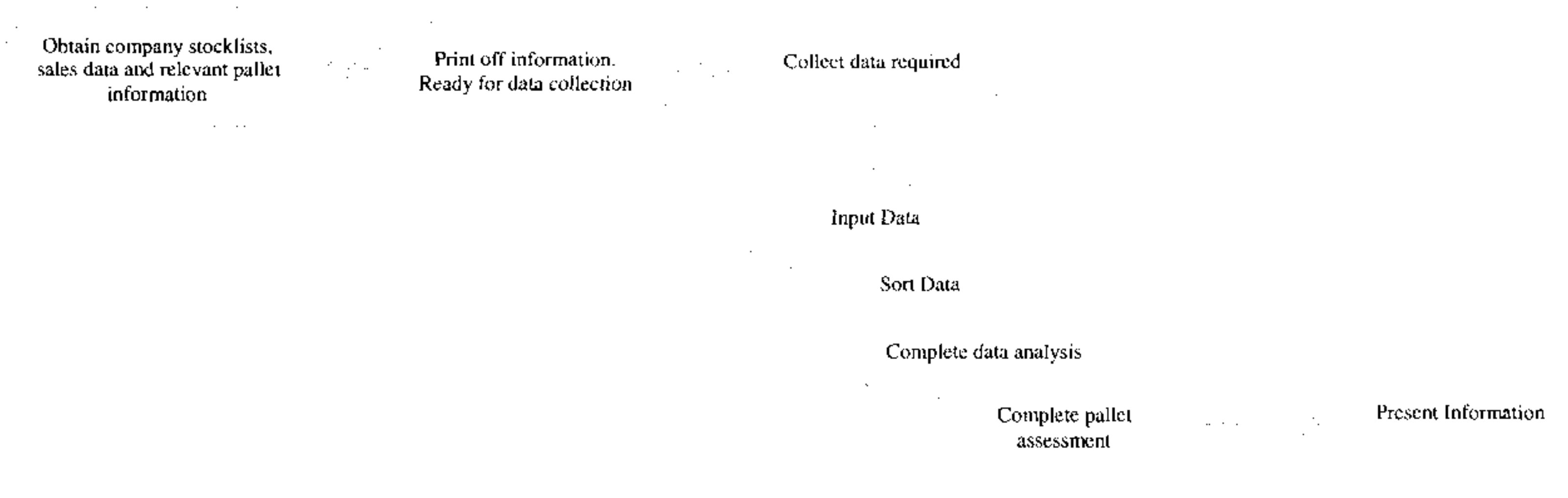


Figure 9-3: Procedure flow chart for the third year of the Retail Packaging Analysis System

9.5. Summary

This chapter reviewed the designing and testing of the procedure manual that was written for this project.

This chapter is very brief because on the nature of the work involved. The manual is written based on the work and experiences leading up to this chapter, therefore writing the procedures was an easy task. Only after this point did testing and in depth proofing need to take place. After this was completed the manual could finally be proof read and then accepted by the client.

This chapter also introduced two new sections of work. These are the future direction of the project and the use of a quality check to ensure that the data collected in the year before is still legitimate.

The final procedure manual is simple and easy to use but still proves that detail that is required to complete the project in an accurate and resources sufficient manner.

Chapter 10. Conclusions and Recommendations

10.1. Introduction

This thesis has summarised the Design and Development of a System to analysis the total volume of retail packaging in New Zealand. The process designed to complete the project was researched and tested in order to increase the efficiency of time and financial resources and to increase the level of simplicity for future attempts to complete the same project. The research consisted of gaining an understanding of the tools and the procedures of project management. Secondly the research delved into the design and development of a statistical based sampling programme. From here the data was collected and analysed in order to generate conversion equations and conversion rates. These equations and rates could then be used to analyse the estimated weights of the products, by multiplying this information by sales data then the total volume and subsequent material and origin of packaging analysis could be made. The final stage of the project involved writing the procedure manual that outlined the steps involved in completing the project.

10.2. Project Management

10.2.1. Conclusions

This project used project management as its means to develop a plan and lay down objectives in order to complete the plan and meet the requirements. The theory of the project management tools that were used was sound, the methodology that was subsequently developed was also very organised and structurally strong. The use of Work Structure Breakdown to analyse the tasks that needed completing was very successful, as too was the use of Conversion Diagrams to analyse the inputs, throughputs and constraints. However the time management of the project failed. This project depended hugely on the availability of information. However, today's industry does not allow the free accessible information that it once had. Constantly this project was held up and delayed because of the delay in, information changing hands or because the signing of confidentiality agreements. This was bound to happen in a project of this magnitude however it was not expected to this level. The use of the Gantt Chart was ideal, the ease of shifting tasks made the problems that endured a lot simpler.

10.2.2. Recommendations

Project Management should become a lot easier for this project in the future. The Procedure Manual that has been written outlines the tasks to be complete in order to complete the project. This manual was tested and there were no foreseen difficulties with it. However, it is important that the future project management team for this project should have previous experience in running projects, dealing with industry, managing funds and staff and also some exposure to packaging and Microsoft Excel or Microsoft Access would be advantageous.

This retail packaging assessment system was developed using a range of project management tools. Thus, the system is in place, therefore should be no reason for large time delays or confusion as what needs to be completed.

10.3. Sampling Methodology

10.3.1. Conclusions

This thesis summarised the design and development of a sampling methodology that would reduce time and the consumption of resources. Designing a sampling methodology whilst remaining in the realms of statistical boundaries was an extremely difficult task. It was decided that the best way to develop the process was to draft a flow chart based on the knowledge gained from the literature review and then through the actual data collection use iterations to slowly develop and improve the process. This worked extremely well. The main developments were in the use of company stock-lists instead of the collection of nominal data and the breakdown of packaging material types for ease of identification. After 9 iterations were completed the final sampling methodology process was derived.

10.3.2. Recommendations

The sampling methodology designed and developed through this project should continued to be used in the future. With the complexity of the project and the nature of the data, the output in terms of the process is both statistically sound and simple to use. Therefore the process as per the procedure manual should be followed.

There should however be an ongoing parallel investigation into the reduction of time through the use of the stores themselves. This could be done in one of two ways:

As a part of company procedure each product on the database or mainframe system should have the estimated package weight attached to them. In this sense the store can track its package and waste use and the procedures will be completed independent of the PCNZ.

The second option is that the staff in the store are used to assess the packaging with project managers employed by the PCNZ. The benefit for the store is that promotion in recycling and waste concern to the public could have positive repercussions on their business.

These ideas should be investigated. Once these processes are in place then the time and monetary resources used by the council will be minimal.

10.4. Conversion Equations and Conversion Rates

10.4.1. Conclusions

The conversion equations and rates that were generated by this project were an experiment. In 1998 when this project was first attempted the conversion was calculated using just a single rate. There was no consideration into whether or not the relationship between net weight and package weight could involve two variables. In the attempt to remedy this, data was collected from a net gross weighing system and the results were plotted to estimate regression equations. The correlation's of all the graphs met the standards that were derived by The Department of Statistics New Zealand. Thus, the equations could be used to estimate the package weights.

However using this method had a major downfall. This was due mainly to the overfilling of products.

The outcomes of the Sample Method Design was conducted under the assumptions that:

- The weight on the label on the product will be assumed to be the true weight of the product in the package. Thus a 60-gram packet of crisps will contain 60 grams of product.
- Volume will be converted to weight using the theory of one millilitre of water weighs one gram. Hence, a 500-ml bottle of coke will contain an estimated 500 grams of product.

These assumptions proved to be incorrect. For example PNC4's data was changed and a new conversion equation created because of this. If for example the industry standard were to overfill products by 5% to ensure no underfilling occurred, then that 5% would be carried all the way through the process that was developed.

Unfortunately this was not evident until all the work was complete.

10.4.2. Recommendations

Without the authority to perform destructive testing on the packages this is the best and most accurate method of assessing package weight. A closer study into the technology of packaging may assist the redevelopment of these equations in the future. However for now, the three-year cycle that was designed and set out in the procedure manual should compensate for the change of technology.

Secondly a complete review of the food manufacturers process in overfilling should also be conducted. This will allow for a greater accurate development of the conversion equations.

A closer study into the effects of overfilling would be of huge help to the project. From this standpoint it hard to estimate what were the direct effects of overfilling. If this method was to continue then this study would need to be completed.

10.5. Procedure and Conversion Equation Manual

10.5.1. Conclusions

The complete project was designed, developed and then transposed into two manuals that describe the steps involved in order to complete the project. The general procedure manual outlines the procedures involved in collecting the correct information prior to the project commencing, the steps involved in collecting the correct data and the steps involved in assessing the data using Microsoft Excel. As a separate document the conversions equations manual describes each package category, the most common examples, a photo of similar type packages and the equation that has been derived. The manuals were tested in the same situation and there were no problems with the procedures.

10.5.2. Recommendations

If each of the steps described in the manuals is followed then there shall be no errors. However, the most important step in the process is the required information that is set out at the beginning. The huge delays and lengthy drawn out experience that this attempt experienced were due to the complications with data. Both Woolworths and Pak N Save use a mainframe based computer system, which means that only a hard copy of the stocklist could be issued. Once the availability of an electronic form of the data from AC Neilson was present then the project was completed within two months. However prior to this point both sets of data were entered into computer manually. This process took almost 2 months.

The most important stage of this project process is getting the foundation right, that is the right product information and national sales data before any data collection takes place. If this is done then the project should consume the time estimated in procedure manual.

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Appendices

Refer to CD. Here is a contents and list of files on the CD.

Conversion Diagrams.doc

Conversion Equations Manual.doc

Estimated vs Real Package Weight.xls

List of Catergories.doc

N Z P C report August 2002.doc

PCNZ data Aug 2002.xls

PNC1 Data.xls

PNC1-PNC5 Data.xls

PNC4 Reassessment.xls

PNC5-End Excluding PNC 7 and 8.xls

PNC7.xls

PNC8.xls

Procedures Manual.doc