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The Development of a Computer Human Interface using Touch Input for Point of Sale Applications

A thesis presented in partial
fulfilment of the requirements
for the degree
of Master of Technology
in Product Development at
Massey University

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1998

This was a joint project between PEC (New Zealand) Ltd. and Massey University.



Abstract

This project developed a touch screen interface for a new generation EFTPOS sales terminal at the fuel pump in a service station.

Scenario plans and creative observation of consumers and analysis of their expressed needs, wants, and requirements were developed within the context of the client's specifications. This enabled the production of a physical and graphical user interface that provided initial appeal, ease of learning, high speed of user task performance, low user error rate, subjective user satisfaction, and user retention over time.

Using multimedia computer software as a rapid prototyping tool enabled realistic feedback to be obtained early in the development stages and facilitated the modification of prototypes to minimise the barriers to potential consumer acceptance.

The designer was able to effectively communicate the goals and details of the product to the team implementing the design using flow charts and diagrams to define the structure and content of the interface.

The process used to develop the interface was compared with published product development techniques that incorporated consumer testing checkpoints throughout the discrete phases of product creation. It was determined that the generic processes were useful in practice, but only if the checkpoints were chosen appropriately and the tests customised for the developing product.

Testing at fixed stages in the design process was found to be detrimental to the project. Putting excessive emphasis on the testing of the product curbed creativity by removing valid solutions before they could be investigated fully.

The touch screen interface developed will be used to lead customers through fuel deliveries, Electronic Funds Transfer (EFT) transactions, and the purchase of other service station related products and services. The interface allows incorporation of advertising and customisation for use in other countries, meets the company's specifications, and has polled well in consumer tests when incorporated in a simulated mounting.

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I Introduction

The project was commissioned by PEC (New Zealand) Ltd, a company specialising in innovative and high technology products for the oil and security industries.

The product required was a touch screen graphical user interface that was to be incorporated into a Forecourt Service Terminal (FST) being developed by the Company. The point of sale device would be located at the petrol pump in service stations. The FST would allow customers to purchase fuel and other products using EFTPOS, fuel, or local cards at the pump. The FST builds upon another product that PEC currently have on the market that enables a customer to purchase fuel using an EFTPOS card at the pump.

The projects joint aim was to present a practical application of the theoretical product development process and to apply generic product development techniques to guide the project through the appropriate design, prototyping, and testing phases.

The theoretical product development process as applied to the interface development was as follows:

- Clarify PEC's needs;
- Analyse current systems and practices;
- Define product specifications;
- Generate product concepts by creating a simple storyboard based on the specifications then develop the storyboard to incorporate innovative options;
- Develop selected product concept and produce a multimedia interface to fit;
- Conduct initial consumer testing to canvas consumer and technical opinion, then modify the storyboard and prototype accordingly;
- Develop the physical aspects of mounting the user interface and model the options;
- Develop product detail and prototype the interface on the computer;
- Consumer test the product to identify areas of acceptance and areas for modification;
- Refine the product design and repeat testing and modification until stakeholders are satisfied with the design;
- Prepare a formal project report;
- Submit the product to PEC for incorporation into the next stage of manufacture.

The resulting touch screen interface is innovative, technically sound, is inviting to customers and easy to use, allows incorporation of advertising and customisation for use in other countries, meets the companies specifications, and has polled well in consumer tests when incorporated in a simulated mounting.

Published product development techniques which incorporate consumer testing checkpoints throughout discrete phases of product creation were found to be useful in practice, but only if the checkpoints were chosen appropriately and the tests customised for the developing product. Generic methodologies need to be translated and adapted for the particular product area and type.

2 Project Background

2.1 Sponsoring Company

PEC (New Zealand) Ltd is a company specialising in innovative and high technology products. They have been working to meet the needs of customers, including oil and security industries, since 1947. Under the main PEC (New Zealand) Ltd umbrella there are three business units:

- Retail Solutions - world leading retail automation systems,
- Cardax – integrated security access control systems, and
- Pumps – sophisticated fuel dispensing equipment.

All the business units are based at sites located in Marton, where each unit can benefit from the technologies used and developed by the company. PEC currently houses an extensive multidisciplinary product development group consisting of over 100 technologists.

PEC's products include point of sale, fuelling, and security control systems, and are sold in over 30 countries.

2.2 Rationale

In 1991, PEC began the design and development of a card reader system to be located in the head of existing petrol pumps. This product would allow for the purchase and payment of fuel at a pump on the forecourt of a service station. Similar products combining a card reader with a pump had been available for a short time on the international market and had a small following. It was PEC's vision to redesign an indoor point of sale unit for mounting at the pump to create a "Forecourt Service Terminal". Unlike a straight card reader and pump, the unit would have the capability to sell more than just petrol. For PEC, the development of the Forecourt Service Terminal (FST) was a natural progression building on their experience with both card reading and petrol pumps in their existing product lines.

2.3 Current Product

In 1993 tooling for a prototype run of Forecourt Service Terminal (FST) units was completed. The first FST units were then produced for customers in Brazil and Hong Kong. The units were purchased by the customers for very different reasons. For Brazil the purchase of around 60 units came at a time where policy changes meant that service stations were being upgraded. The fitting of the FST units added an extra feature for the service station at a minimal extra cost. For Hong Kong, with extremely busy roads, the installation of the FST units increased productivity at service stations while decreasing fraud. Each pump and FST could be assigned to a different attendant (attendant tagging), with all sales being run through the FST by either the customer or the attendant. FST units have since been installed in New Zealand, Australia, South Africa, and Malaysia.



Figure 2.1: Current Forecourt Service Terminal (FST)

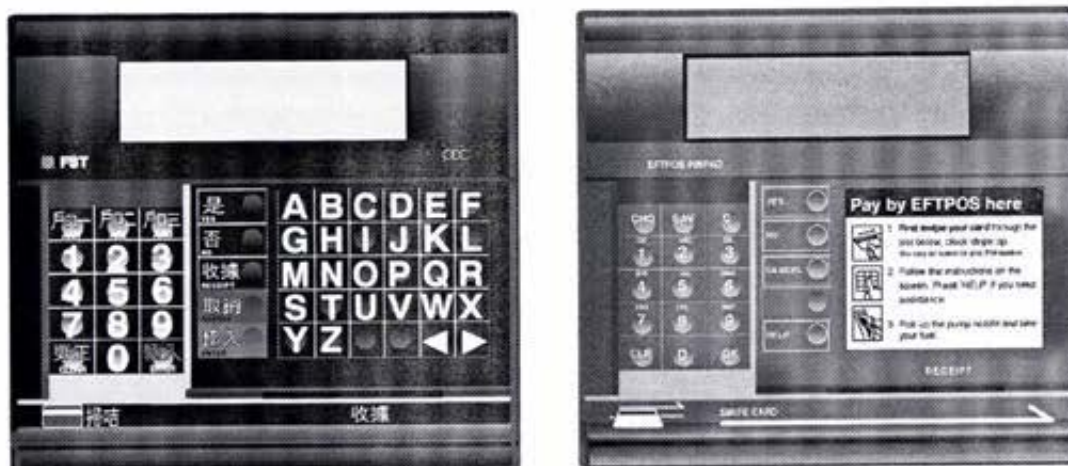


Figure 2.2: Forecourt Service Terminal (FST) variations

The FST is produced in three different colours of plastic, which is then pad printed with the appropriate text. There are currently around 15 variants of the FST front. Each customer has their own combination of colours and text, making the front end of the unit a costly item to produce, and an item which can only be sold to the one customer. Due to the high level of customisation of the FST front, holding the unit in stock is not cost effective.

The FST has been very successful. The tooling, which was intended to cover a prototype run of no more than 500 units, has produced around 14 000 units to date.

The first major break in technology for the FST came from a need to include Smart Card transactions in the South African market. The use of different types of card was not envisaged in the initial design of the FST, but a successful solution was found.

2.4 Product Intent

The FST had always been sold as a unit with the capabilities to sell other products, however, in reality when a customer wanted to be able to sell oil from the FST, it required extensive input from software engineers to add that one function.

Changing the original design to include today's additional requirements is becoming harder and more time consuming. The cost of customisation is inhibitive.

In 1994, PEC began work on a model upgrade for the FST. The reasoning behind the upgrade was to provide a system that required less support from PEC staff. This upgrade would be achieved by producing an FST that was driven more by the software than the hardware, allowing the unit to be customised more easily.

The development of concepts for the new FST were based around known strengths and weaknesses within PEC's existing range of products. The major strengths identified for the current FST unit included:

- The ability to be mounted into the majority of existing petrol pumps,
- The ability to be combined with another PEC product, a site controller, to supply a complete service station solution.

The new product had to be easily customised, with functionality that was flexible to meet the needs of individual markets. It was decided that using a flat panel Liquid

Crystal Display (LCD) screen with a touch overlay in the FST mark 3 would provide a suitable solution to facilitate customisation. The physical user interface would be able to remain the same throughout all the models, while the screen would contain the customisable text, graphics and content.

3 Project Plan

3.1 Project Outline

PEC (New Zealand) Ltd approached Massey University with a potential Graduate Research in Industry Fellowship (GRIF) project. The project was the development of a computer human interface using touch input for point of sale applications.

The idea behind the project at the start was to produce a touch screen interface that could be used to lead customers through fuel deliveries and Electronic Funds Transfer (EFT) transactions. The interface would also be used to perform other transactions, service station related services such as car washes and dry stock sales, and non service station related services such as fast food sales from an attached franchise outlet.

Massey University accepted the idea and identified a possible student. Following the selection of a student, a joint submission by Massey University, PEC (New Zealand) Ltd and the student was made to the Foundation for Research, Science and Technology (FRST) for GRIF project funding.

The project was accepted by FRST to receive GRIF funding, and a job description and basic plan were compiled for the student by PEC. The basic plan summary follows:

Development of a Storyboard

- Duration 8 weeks;
- Research areas – Background on current system and project requirements, relevant banking requirements, understanding the technology to be used, and research in operating background.
- Output – Flow diagram, Storyboard, Report, Working model on computer.

Display Investigation

- Duration 12 weeks;
- Research area – Operating environment, capability of LCD displays, research into colour combinations suitable for application, means or reproducing the viewing angle of screen for security modes.
- Output – Report, working demonstration model.

Icon Research

- Duration 5 weeks;

- Research and design areas – design icons that will negate the need for words to use the product, research other graphical interfaces such as EFT, information kiosks, web sites, and other unmanned interfaces.
- Output – Report, updated computer model.

Touch Interface

- Duration 5 weeks
- Research and design areas – Research and design button/touch including visual feedback, audio feedback, speed, and how they should work.
- Output - Working prototype on computer.

Human Reaction

- Duration 12 weeks
- Research and design area – Extensive research into personal reaction to different types of interface, colours, graphics, animations, sounds, prompts, help needs, and information flow.
- Output – Report and working prototype on computer of best solution.

Help Definition

- Duration 8 weeks
- Research and design areas – An extension of the human reaction studies concentrating on help requirements.
- Output – Report of help requirements of the interface.

Finalisation

- Duration 10 weeks
- Output – Finalise working computer prototype.

3.2 Development Process Plan

Using the job description and the PEC proposed project plan as a guide, the following plan for a development process based on the style of Ulrich and Eppinger (1993) and Moore and Pessemier (1996) was prepared.

Clarify Companies Needs

- As identified by PEC in the project outline.

Analyse Current Systems and Practices

- Familiarise with company, personnel, and company products.
- Familiarise with related technologies and similar products.
- Research the associated literature.
- Conduct analysis of user profile:

- Service station users survey,
- Focus group,
- Observational analysis.
- Identify technical factors that would impact on the product specifications.
- Identify and address additional personal skills required to carry out all aspects of the project.

Create Product Specification

- List a precise description of what the product needs to do and comply with.

Generate Product Concepts

- Create a simple storyboard based on the specifications.
- Develop the storyboard to include further identified options.

Technical Content Testing

- Interview company experts in areas of component processes as identified in the storyboard.

Develop Product Concept

- Develop an interface to fit the selected storyboard.

Initial Concept Testing

- Assess consumer reaction to the storyboard using the developed interface.
- Modify storyboard and interface in direction required by consumer sample and company technical experts.

Physical User Interface

- Investigate ways to mount components in a forecourt environment.
- Develop company's choice of mounting.
- Model alternatives for the chosen mounting location.

Detail Development

- Refine, modify, and add to graphical user interface.
- Prototype interface on computer.

Consumer Testing

- Assess individual aspects of the interface content.
- Construct test area to house interface prototype.
- Formally test Graphical User Interface (GUI):
- Study of consumers interaction with product,
- User questionnaire,
- Identification of areas of excellence and areas for improvement.

Modification of Prototype

- Improve aspects or areas of the interface identified during testing.

Refine Product Design

- Repeat consumer testing and modification until the company is satisfied with the product design.

Prepare Report

Submit Product

- Submit product to company for incorporation into the next stage of the FST development and manufacture.

4 Initial Research

The overall project was separated into four main aspects:

Multimedia

- Technologies
- Content

Consumer

- Observation
- Survey

Ergonomics

- Physical
- Cognitive

Product Development Process

- Theoretical
- Applied

Initial research in the form of a literature review, consumer survey and observation, and a technical review was carried out. The research aimed to determine existing knowledge and applications of the identified aspects, in order to form a basis with which the development of the Forecourt Service Terminal could structured around.

4.1 Literature Search

4.1.1 Multimedia Literature

Defining Multimedia

Multimedia has been defined as the simultaneous use of more than one media type on a computer (Murie, 1993). The basic types of media available on computers are:

- Text,
- Graphics,
- Animation,
- Video, and
- Sound.

It has similarly been defined as the seamless integration of text, sound, images, and control software within a single digital information environment (England and Finney, 1996).

England and Finney (1996) give a summary of influencing factors for the use of each of the different media types as follows:

Video

- Video uses more space than other media and may affect the interaction speed.
- The display size of any video needs to be appropriate for the content, needs of the viewer, and platform.
- Video graphics can be faster to produce but more expensive than computer graphics.
- Video graphics can give a continuity of style in applications where video features.

Audio

- Audio is a versatile and cheap medium.
- Saves the overuse of text.
- It appeals to emotions.
- Its range and scope are unappreciated in most multimedia to date.
- Care is needed for sounds that become irritating when repeated in an interactive environment.

Graphics

- These are versatile and have a wide range of quality.
- They can offer realistic and symbolic representations.
- Research findings indicate that graphics have value in all applications.

Text

- Over time text has changed its role to a supportive one rather than a main component.
- Although used less now, care needs to be taken to ensure that the text content keeps its quality in line with the other media components.
- Integrating text and maintaining quality can be difficult.
- Layout, size and legibility are important.
- The new ways of organising text in interactive environments can pose problems for some users.

Multimedia is most often used for presentations, training and education programs, sales demonstrations, information kiosks, games, and database front-ends. It is a technology that exists in many applications, and users are now expecting it to be a part of what a computer 'does' rather than some unusual feature (Murie, 1993).

Multimedia Tools

Icons

Research on icons can be linked with that on signs and symbols.

The use of symbols probably began fifty thousand years ago when man made his mark using simple abstract strokes cut into rock or bone. A symbol stands for something. It is visually precise. A symbol attempts to get at the essence of an idea either by being a literal miniature drawing or by being a non-literal visual metaphor. A symbol can give an identity to a subject and, by repeated use, can come to equal it (Holmes and DeNeve, 1990).

The elements used to create a quickly understood symbol are the basic graphic shapes: circles, squares, diamonds, triangles and so forth. Each element comes with its own meanings, and when put together with each other in different combinations, the shapes can become very potent. Adding colour to the elements increases the range of possibilities. However, reliance on colour can be dangerous (Holmes and DeNeve, 1990).

In multimedia any pictorial representation that a user can select is called an icon. But in the theory of signs, icons are images that are readily recognisable. They are not symbolic, but realistic to the extent that they are recognisable without explanation. Commonly, icons in multimedia encompass the complete range of images from abstract symbols to realistic representations. The user quite often has to learn what the symbols mean to use the icons effectively (England and Finney, 1996).

Dreyfuss (1972) separates symbols into three different types:

Representational

- Representational symbols present fairly accurate, if simplified, pictures of objects.

Abstract

- Abstract symbols reduce essential elements of a message into a graphical form. These may once have been representational but have become simplified by design or degrees over many years, to the point where they now only exist as symbolic indications.

Arbitrary

- Arbitrary symbols are those that have been invented, and accordingly must also be learned.

England and Finney (1996) indicate that there is no equivalent to the miniature moving images sometimes used in multimedia interfaces, as sign theory relates only to static images.

Interactive media allows for the combination and manipulation of information in new ways, with icons forming a part of the new vocabulary. Icons show that the user has choices and try to indicate what sort of information could be activated if the icon is selected.

It is important that any new symbols used are suitable for the markets the product is intended for. According to England and Finney (1996) there have been many examples of cross-cultural misinterpretation of symbols.

It is also important to limit the number of icons in use on an interface. If there are many icons, it will take the users a longer time to learn their meaning (England and Finney, 1996). This problem is accentuated in multimedia applications where the users are not expected to spend much time on the systems (ie. Kiosks).

Icons are often related to everyday objects to convey their meaning. Using a metaphor such as a book or an office has been used successfully with individual icons relating to specific details consistent with the metaphor. This works until the concepts that the icons must deal with are new to the metaphor. A compromise to this solution is often to use a text name in addition to the icon. However, guidelines for international use do not recommend this practice. Text names often cause problems when they are translated, as they frequently cannot be fitted into the same space (England and Finney, 1996).

According to England and Finney (1996), a lot of progress has been made in multimedia design due to the use of icons. Overall icons provide better access to the systems functionality despite their limitations. Instead of having to remember sets of symbols and codes like computer languages, icons provide prompts to help anyone activate the power hidden in the application.

Sound

Sound refers to any type of audio use. This can include speech, warning bleeps, alarm bells and so on. As sounds became easier to digitise, it became apparent that overuse was unwise. People became irritated by repeated sounds (England and Finney, 1996). Some sounds that are initially attractive or entertaining pall quickly.

Schuck (1994), investigated the use of auditory feedback in the design of touch input devices. In an experiment performed using a touch screen keyboard to type random characters and English words, testers were timed with and without auditory responses to their key presses. The results indicated that the addition of auditory feedback had a significant effect upon typing performance in the use of touch screen input devices. Speed of response was shortened with the addition of auditory feedback with the number of errors made not being affected.

Colours

There can be several uses for colour such as attention cues, aesthetics, styling and branding (England and Finney, 1996). As with the use of sound, colour can please initially then become annoying for users.

Colour displays are attractive to users and can often improve task performance, but the degree of misuse is high. According to Shneiderman (1992) colour can:

- Soothe or strike to the eye,
- Add accents to an uninteresting display,
- Facilitate subtle discriminations in complex displays,
- Emphasise the logical organisation of information,
- Draw attention to warnings,
- Evoke strong emotional reactions of joy, excitement, fear or anger.

The use of background colours, the colour of text against a coloured background, colour linked with layout and the awareness of colour-blindness in a percentage of the audience were all factors that were researched before the availability of high-resolution screens and high quality colour. The main problems arose from poor selection of colours in relation to each other causing difficulties in reading and legibility (England and Finney, 1996).

According to England and Finney (1996) one of the problems that still prevails is the changes in colour that occur due to their origins, the platform, the software, and the encoding process. Even with good planning colour shifts can occur.

There are cross-cultural associations in the use of colour. This is part of the aesthetic appeal of colours but it may become important as applications need to reach international audiences. Some cultures respond better to bright, strong, primary colours and other cultures prefer pastels (England and Finney, 1996). For applications that are intended to sell products, this could be more of a factor than other types of application.

Some common examples of Western colour psychology are:

Red	=	stop, danger, heat
Blue	=	cold, water, sky
Green	=	go, environmentally friendly

Research in the area of colour psychology is ongoing.

Multimedia Products

England and Finney (1996) have divided multimedia products into the following categories:

Presentation

- This is a growing source of business multimedia. Applications of this type of presentation include conference presentations and presentations for corporations to help project an internationally competitive company image.
- Tools for computer based presentations are now making it possible for many people to produce the lower-level forms of multimedia presentation.

Point of information (POI)

- There are a wide range of applications that fit this category, from tourist information systems to applications in museums that give specific information about exhibits. These systems are often intended for use by the general public.

Point of sale (POS)

- These are retail projects where the application needs to sell products. These systems are often confused with Point of Information since the customer can usually get information on the products before requesting a sale. The deciding factor determining the success of a POS is whether the customer will commit to buying an article on the spot.
- Kiosks, of which POI and POS are types, are a significant area for multimedia. These require sophisticated and attractive user interfaces to encourage public use. Since kiosks are usually specially designed systems, the hardware configuration can be chosen so as to be the best for the task with few constraints other than cost.

Training

- The training market has in the past been one of the strongest for multimedia. There is a strong emphasis on defining the expected changes in the users behaviour as a result of using an application.

Advertising

- Advertising agencies are beginning to recognise the potential that multimedia might offer. This sector is likely to grow as advertisements are made more interactive.

Education

- The standardising of curricula means that this is a potentially large market.
- The Internet is one such technology. It started as a text-driven method of communication, and is changing rapidly into a distributed multimedia channel for not only higher education but for business as well.

Publishing

- Included in this category are record, audio-visual, and book. Some of the more popular examples of multimedia titles developed in this area include atlases, road maps and encyclopaedias.

Multimedia has been described as having “a chameleon-like ability to pretend to be many things” (England and Finney, 1996, p2). The developer has the freedom to use any number of media types and techniques. For the end user, the

use of multimedia in the intended environment can improve the flow of ideas and information.

A secondary side to multimedia is interactivity. Interactivity being, the capability for the user to interact with the multimedia production, causing things to happen or interrupting the flow of information. Interactive multimedia descends from computer-based training by way of interactive video. Good interactive video using videodiscs is only now being surpassed by all-digital multimedia (England and Finney, 1996).

Designing a Multimedia Product

According to Murie (1993), designing and producing a multimedia project involves three major tasks:

Design

- The process of coming up with the idea.

Production of elements

- Creating the different media elements that will be used in the project.

Implementation

- Taking the elements and putting them together based on the original design.

A comprehensive breakdown of the project cycle has been covered by England and Finney (p6, 1996) in figure 4.1 reproduced on p18.

Further description of the England and Finney (1996) project cycle is summarised below:

The definition stage

- Gaining an understanding of what the clients want – ‘scoping the project’;
- Project timescale;
- Definition of costs;
- Project proposal to clients.

Production

- Level 1 - Defining the developer / client relationship;
- Level 2 - Defining details relating to content, platform, media and techniques;
- Level 3 - Recruitment of personnel (completed in parallel to level 2);
- Level 4 - Asset creation. The production of the multimedia components;
- Level 5 - Administration of rights for material used (in parallel to level 4);
- Level 6 - Specificity testing of individual pieces and the integrated components;
- Level 7 - Final sign-off by client;
- Level 8 - Documenting and archiving project to aid with return business and upgrades.

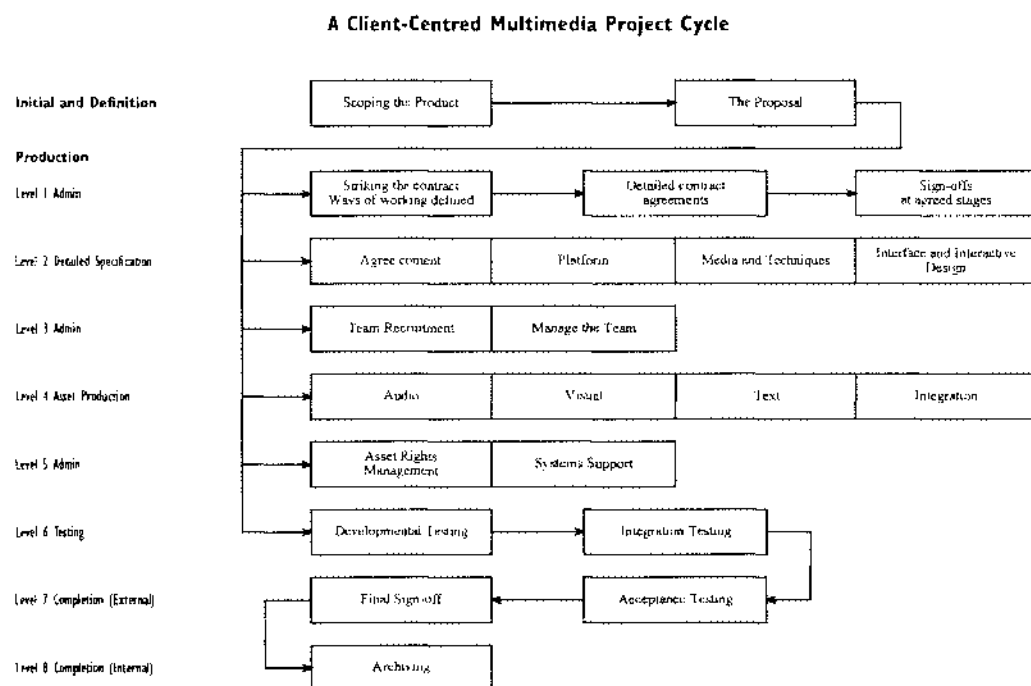


Fig. 4.1: Client Centred Multimedia Project Cycle (England and Finney, 1996, p6)

Murie (1993) details the project cycle in six steps:

The idea

- Every project begins with an idea, goal or purpose.

Establishing the constraints

- Before details of the product can be worked on, the constraints for the project need to be defined. The most obvious constraints include cost, time and materials. Some less obvious but equally important constraints include, defining who will use the product, what they will use it on, and what they expect from the product.

Planning the production

- Three elements effect the planning of the production, the authoring environment, the data, and the user interface.
- The authoring environment is the program used to create the multimedia production and to bring all of the media elements together.
- The data is the main part of the production. It is the information that is to be conveyed to the user.
- The user interface deals with how the user will interact with the data. There are two main elements in interface design, structural elements and cosmetic elements. Structural elements include items such as menus, data fields, windows and buttons. These elements must be defined early in the development process (Murie, 1993) as changing these elements involves large changes in a project. Cosmetic elements refer to items such as the background graphics and the shape of the icons.

Creating the prototype

- To produce a multimedia product by building a complete prototype and then building the final product from scratch is in Murie's opinion costly on both time and resources. The alternative he proposes is to work in 'chunks'. The first chunk, which provides the framework, being the implementation of the system structure. He indicates that graphics should be designed after the system structure has been completed.

Adjusting the prototype

- Throughout the prototyping, consumer testing of parts or all of the system should be carried out. This allows the developers to see what users think, and then add to or change the prototype.
- Murie advises that testing is most valuable when input is gathered from as many sources as possible. When testing an interface, the most useful result is gained by using someone who has never seen the project before. It is beneficial not to tell the user how to do anything, but to watch what they do.
- One way to insure the developer has no input into the evaluator's actions is to have tests videotaped. With a video, the developer is not in the same room as the tester and therefore cannot interfere. The other benefit of a video is that the tape can be watched over and over again.

Final delivery of the project

- The final delivery is the completion of the project.

Assessing the Quality of Multimedia Products

The quality of individual aspects of a multimedia product may be able to be defined specifically: for example, audio feedback being mono or stereo. Defining the quality of design is subjective (ie. every person testing a multimedia system design looks at the aspects of the system that mean the most to him or her). The difference in perspective among the testers makes consensus difficult. In each project there will be some technical aspects but many subjective aspects for design quality.

According to England and Finney (1996), the best solution to date for assessing the quality of a multimedia-based product is to define a set of criteria that the product is to meet before any other decisions are made. Each project will thus define its own 'quality' priorities according to the subject and target audience.

England and Finney (1996) used the following equation to define design quality:

Design quality for media projects = content and treatment agreement

- The content means the information that is going to be presented.
- The treatment means which media and which techniques will be used and what it will look like.

The Multimedia User Interface

Each multimedia application has an infrastructure that links the component parts together so that users understand what the application contains, how the information is organised and what they need to do to activate the separate pieces. This structure is more commonly referred to as the interface. The aim of most interfaces is to provide smooth, easy access to any part of the program the user wishes (England and Finney, 1996).

Ravden and Johnson (1989) define the user interface as the programmable, or software, interface that enables the end user (ie. the person using the computer) to access and interact with a computer application system, to make use of the

facilities and functions which it provides, and to carry out the tasks for which the system has been defined.

The user interface generally consists of information displayed to the user and facilities which allow the user to enter information into the computer, to manipulate information which is displayed, and to take control actions. It enables the end user to access and make use of the facilities and functions that the system provides, and to carry out the tasks for which it has been designed. The user interface provides the user with information about the system, about what it does, and about what the user can and should do. It enables the user to learn about the system and to build an understanding of how it works (Ravden and Johnson, 1989).

Ravden and Johnson (1989) indicate that if the interface is poorly designed, it can severely restrict the user's ability to use the system. It can cause confusion and frustration, difficulty in learning how to use the system, misunderstanding of what the system is doing and of what the user should do, errors, and difficulty in using the system to carry out tasks successfully.

For today's users, communication with a multimedia system has become at least as important as the computation by the system. "To users, the interface is the system" (Hix and Hartson, 1993, p1).

England and Finney (1996) explain that when text was the dominant medium applications were structured through menus. The user had a choice that led to another text menu and so on. The user went down through the levels and returned by selecting 'exit' or the equivalent. This type of structure has become known as a tree structure. There are variants on this structure, which allow the user to select routes other than the reverse decision to return to the top level.

As it became easier to include graphics, icon-driven menus started to become common. England and Finney (1996) identified the following advantages that icons have over text:

- They may take less space than text;
- They are not language specific;
- They are aesthetic and appealing;
- They can make access through the application easy.

Usability Testing

An alternative to testing the quality of the multimedia system is to test the usability of the user interface. The need for user friendliness is often heard, however, most users are not looking for a friend in the computer but rather hassle free productivity. The real issue is usability.

The human-computer interface, or user-interface, represents the only part of the application system that the end user comes into direct contact with. The user-interface therefore plays a vital role in enabling the human to 'use' the system (Ravden and Johnson, 1989).

Usability has been defined by Ravden and Johnson (1989) as the extent to which an end-user is able to carry out tasks successfully, and without difficulty, using the computer application system.

Tom Carey (c. 1992) (quoted in Hix and Hartson, 1993) a lecturer in the department of Computer Science at Virginia Tech, USA had the following to say on usability: "If your computer were a person, how long 'til you punch it in the nose?"

Shneiderman (1992) divides usability into the following user-orientated characteristics:

- Ease of learning,
- High speed of user task performance,
- Low user error rate,
- Subjective user satisfaction, and
- User retention over time.

England and Finney (1996) indicate that multimedia does not have a strong tradition of testing. It has not developed a clear relationship with the methods of testing from other disciplines and has not devised its own.

The importance of usability testing to ensure the best interface design is reinforced by Ravden and Johnson (1989). The programmable, or software, interface that allows interaction between end users and the computer plays a vital role in the effectiveness with which a human-computer system functions.

It is therefore essential that the user interface meets the needs of those using the system to carry out tasks.

The importance of user interface design should not be underestimated, and its evaluation should be expected to take some time and effort (Ravden and Johnson, 1989). In the longer term the benefits which are likely to result from the evaluation may outweigh the costs.

Ravden and Johnson (1989) gave the following examples of benefits resulting from a well-designed and tested user interface:

- Reduced training time for end users;
- Reduced support costs, due to fewer and less significant difficulties;
- Reduced need for amendments, modifications and revisions after implementation;
- Where relevant increased sales, as a more useable, well-designed and acceptable product is produced;
- A greater willingness among end users to accept the system and to use it effectively;
- Greater efficiency and utilisation of computer resources;
- A greater awareness, amongst those developing computer application systems, of the requirements for 'user-centred' design.

The Use of Touch Screens in Multimedia

Touch screens are used as the input device for many public-oriented applications because of the ease of use (MicroTouch web page).

According to Keister (1997), it was not long ago that touch screens were specialised tools limited to applications such as process control, military command, and air-traffic control. Reasons for using touch technology in these areas were defined by Shneiderman (1992) in the following list:

- Space is at a premium in these systems,
- Touch screens have no moving parts,
- Users can be guided through complex tasks.

In early studies, direct pointing devices, such as the light-pen or touch screen, were often the fastest but the least accurate devices (Stammers and Bird, 1980; Albert, 1982; Haller et al., 1984). The speed appears to accrue from the directness of pointing, and the inaccuracy from problems with feedback, physical design, and use strategies.

Over time, touch screen technologies have improved. The improved technologies used in the devices have made it feasible to build high precision touch screens and pens. Costs have dropped and parallax errors have decreased with the integration of touch screens during the display-construction process (Shneiderman, 1992).

Up until the 1990's few of the general public had actually seen an operating touch screen (Keister, 1997). This has changed during the 1990's with supermarkets, post offices, restaurants, shopping malls, libraries, gaming establishments, and a variety of other enterprises now employing touch screen technology.

According to Daniel Shore (quoted in Keisler, 1997), General Manager of the AccuTouch Business Unit of Elo Touch Systems, Inc. (Oak Ridge, TN), touch screen suppliers sell solutions to the following four primary markets:

Point of Sale (POS)

- Touch screens simplify cash registers;
- Operator errors are reduced;
- Useful in areas with high employment turnover.

Point of Information (POI)

- Provide access to data in public environments;
- Give fast, easy information in users native language;

- Used in computer-based training systems.

Gaming Systems

- Touch screens are used to make games into more intuitive systems;
- Unlike their fixed button counterparts, touch screen terminals are not limited to one game.

Process Control Operations

- Can simplify man/machine interface;
- Stand up to contaminant-rich environments like factory floors;
- Can be sealed to become watertight, making touch screens more durable than keyboards, buttons, and dials.

Keister (1997) highlighted the following areas where touch screens have advantages over other input devices:

- Easily customised (ie. easy to switch between languages used to display commands);
- Able to be sealed and made water-tight;
- The user has direct contact with the interactive information;
- No computer literacy is required to use a touch-based system.

Carroll Touch (1998), adds to Keister's list with the following points:

- As pointing or touching is a natural means of indicating choice, touch systems are ideal for selection-based applications;
- Selections are made by pointing at the screen, therefore no special software commands are required;
- Hand-eye movements do not need to be coordinated as the user does not need to look away from the screen to a separate input device (ie. a keyboard);
- Many graphic effects are possible. Touch targets can be different shapes, colours, and styles.

Touch screens lend themselves to stand alone displays such as kiosks, and Keister (1997) indicates that the largest market by far for touch screens is the Point of Sale systems. POS systems incorporate not just cash register terminal, but fully computerised networked systems.

4.1.2 Process Development Literature

Generic Product Development Process

“A product development process is a sequence of steps or activities that enterprise employs to conceive, design, and commercialise a product” (Ulrich and Eppinger, 1995, p14)

Moore and Pessemeir in “Product Planning and Management” (1993) have identified the steps in the new product development process based on work done by Booz-Allen (1982) as those shown in figure 4.2:

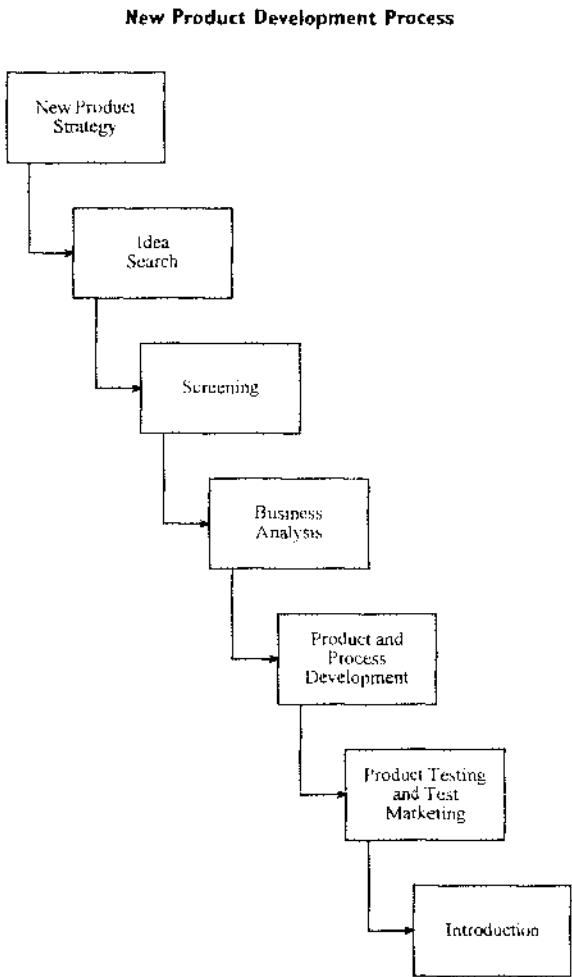


Fig. 4.2: New Product Development Process (Moore and Pessemier, 1993, p95)

Some of these steps will be seen to be intellectual and organisational rather than physical, as described by Ulrich and Eppinger (1995). These researchers also

note that while some companies follow very precise and detailed process steps others are quite random in their approach. This reinforces the idea that approaches are individualised to match company needs and work practices. Moore and Pessemier (1993) also agreed that the best approach may not be known in advance and defined processes need flexibility.

A well defined process however can be useful where it:

- Defines checkpoints against which to measure the quality of the developing product,
- Coordinates team roles,
- Times phases of the project,
- Compares actual events with established process thus aiding early problem identification,
- Promotes ongoing process improvement over time (Ulrich and Eppinger, 1995).

The five phases of generic development processes put forward by researchers Ulrich and Eppinger (1995) are:

Concept Development

- Identification of target market needs;
- Evaluation of alternative product concepts;
- Selection of product for further development;
- Specification of product description;
- Analysis of competing products;
- Economic justification.

System Level Design

- Definition of product architecture, sub-systems, components, and layout;
- Preparation of a preliminary process flow diagram.

Detail Design

- Complete specification of geometry and materials, tolerances, and parts sourcing;
- Established process plan for fabrication is developed.

Testing and Refinement

- Construction and evaluation including early prototypes, progressing to later prototype using actual parts;
- Performance and reliability testing of the later prototype;
- Implementing changes necessary in final product.

Production

- Product preparation using the intended manufacturing system;
- Eliminating final flaws in manufacturing system and/or product.

Managing the New Product Process

Providing the new product in a timely fashion is important if value is to be created in the perception of the customer. Moore and Pessemier (1993) warn of the need to focus on development cycle time and cost management.

Management tools such as planning and process improvement can expedite a products return on investment.

Success of a New Product

Moore and Pessemier (1993) state that the most important factor determining the success of a new product is a superior value in the eyes of the customer. Superior offers are based on a new product idea that meets the needs of the market and a product that lives up to that concept.

To ensure that a new product is given every possible chance of succeeding, Moore and Pessemier (1993) have indicated that the following areas are of importance:

- Initial market research to identify unfilled needs or latent problems.
- An efficient product development process.
- New products that fit within the company's marketing and technical capabilities.
- Selection of a suitable target market.
- Well-directed and funded introduction of the product into the market.

A study of failures in new products made by Cooper (1984) indicated that the reason for most failures is that several marketing activities (eg, detailed marketing study, product testing, and test marketing) are inadequately carried out. A later study by Cooper and Kleinschmidt (1996) relates the success of individual new products to the completeness of the new product development process, and how well each of the steps were executed. Deficiencies in

preliminary market studies, initial screening, and detailed market analysis were cited most frequently.

Hoo and McDonald (1983) asked respondents to indicate which activities needed more effort in order to improve the new product success rate. The activities highlighted were (in order of importance):

- Market analysis and opportunity identification;
- Strategy formulation;
- Concept and positioning development;
- Basic research and development (R&D);
- Idea generation;
- Product development and testing;
- Pre-test market sales estimation;
- Concept test.

During studies of companies with successful new product records, Booz-Allen (1982) found that they were more likely to have a formal new product development process in place. Moore and Pessemier indicate that a new product process should act as a road map, providing direction to new product efforts. It should remind people to go through the relevant steps in the proper order.

In figure 4.2, the process has been made to look linear and orderly. In reality, the process is "usually quite messy" (Moore and Pessemier, 1993, p103). The linear process can also convey the false impression that one functional area works on a part of the process and then hands its contribution off to the next group. However, Moore and Pessemier indicate that an interfunctional group should be assigned to a project from start to finish (ie. preliminary studies should be going on at the same time that technical work is being carried out).

The Booz-Allen chart shown in figure 4.3 is more consistent with the views expressed in Moore and Pessemier (1993). The diagram shows that there is continuous consumer testing and the manufacturing concept is being developed at the same time the product is being developed.

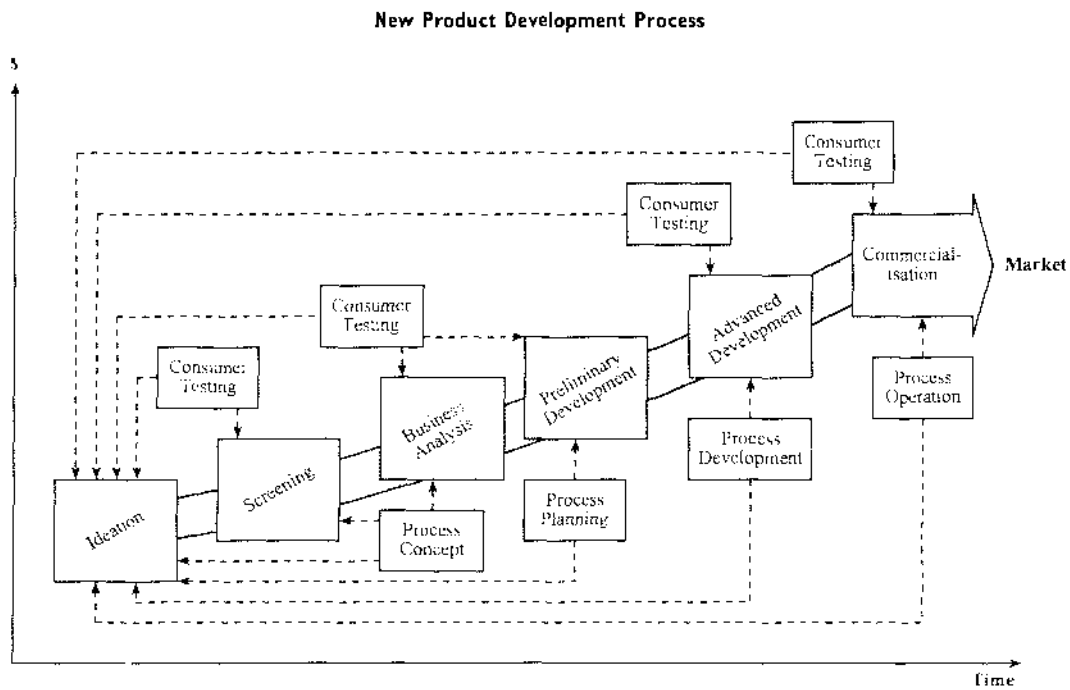


Fig. 4.3: New Product Development Process (Moore and Pessemier, 1993, p103)

4.2 Consumer Studies

A number of studies were conducted prior to the commencement of the new FST product design in order to establish some potential user parameters. These studies were:

- A related technologies questionnaire, and
- A focus group.

4.2.1 Related Technologies Questionnaire

A questionnaire was compiled and left in a service station for customers to complete (see appendix i). The questionnaire was targeted at potential users of the new FST. It asked them to indicate their interest and degree of use in technologies related to the proposed FST. The related technologies included:

- EFTPOS,
- EFTPOS at the service station,
- ATM (Automatic Teller Machine),
- Computer,
- Computer based catalogues,
- Internet,
- Self service petrol fill-up,

- Automatic snack/drink dispensers,
- Drive through at restaurants.

From the questionnaires returned, the following results were noted:

- The majority of respondents expressed a high degree of both interest and use with EFTPOS and EFTPOS at service stations;
- The respondents were less interested in automatic teller machines than they were with EFTPOS machines, and the use of ATM's was lower than the use of EFTPOS;
- The majority of respondents indicated that they were either very interested or not interested at all in computers, the Internet, and self-service filling;
- Most of the respondents indicated a high degree of interest in drive through restaurants but a low degree of use;
- The degree of use for the three computer based technologies was low.

Based on the results of the questionnaire profiles of four main types of potential user were compiled as follows:

Attendant

- It is assumed that an attendant will have been trained to use the equipment and technologies provided at the service station.

Keen

- Confident with dispensing fuel;
- Conversant with different methods of payment;
- Has tried to use the EFTPOS at the pump;
- Would rather complete purchase themselves than let an attendant help;
- Inquisitive.

Average

- Are able to dispense fuel;
- Has used the different methods of payment available instore;
- Doesn't mind if an attendant helps.

Reluctant
either

- Not conversant with all methods of payment;
- Able to dispense fuel;
- Doesn't mind if an attendant helps.

or

- Doesn't like to dispense fuel;
- Avoids going to a service station if possible;
- Lets the attendant dispense fuel;
- Conversant with different methods of payment.

or

- Doesn't like to dispense fuel;
- Avoids going to a service station if possible;
- Lets the attendant dispense fuel;
- Not conversant with all methods of payment .

4.2.2 Focus Group

A focus group of potential users was organised. The aims behind the focus group were as follows:

- To identify areas where the FST mark 3 could be used to improve the current service station environment. and
- To gauge the market acceptance of the proposed FST upgrade.

Initially the group was asked if there was anything in particular that they liked or disliked at the current service stations. The comments made included:

- There is a huge difference between the service they say they offer and the service they give;
- Don't necessarily want the services they provide (windscreen wash, attendant...);
- Waiting in a queue to pay is one of the most annoying things;
- Need better sign-posting of the pump numbers – when going instore to pay, you need to know what pump you used.

The group was then asked what they would like to see in their ideal service station. These were some of the responses:

- Portable EFTPOS machine – don't have to get out of the car;
- No pumps on court, just overhead nozzles;
- A parking base with mobile bowser for orders of fuel;
- Petrol pumps in supermarket car parks;
- A service to wash hands after filling up;
- Go inside and take what you want from the store, as you exit through the door the products are automatically scanned and added to your total.

The group were then told about the concept behind the FST mark 3. A touch screen interface mounted at the pump that would allow them to purchase, and pay for, fuel and other items at the pump.

The general feeling amongst the participants of the focus group was that they would only purchase an item that they didn't need to see before buying. For example, the group felt comfortable about purchasing a can of lemonade, but would not consider buying a sandwich unless they could first see exactly what they were getting.

When asked what type of items they would like to be able to purchase on the forecourt, the following list was compiled:

- Petrol,
- Car washes,
- Chips,
- Softdrinks,
- Sweets,
- Chocolate bars.

When asked about the possibility of the interface offering other services such as road reports, or maps, the opinion shared by the group was that this type of service would cause delays on the forecourt from customers browsing the available information. It was also mentioned that unless map printouts could be offered to those seeking directions, the user would probably need to copy the directions down off the interface.

The focus group participants were then given the opportunity to make comments relating to the proposed Forecourt Service Terminal. These were their comments:

- It would be good to have some pumps which only sell fuel – express service;
- Have an option available that allows you to have no interaction with an attendant;
- Have access to the screen from the car;
- Order items at the pump and pick up like a drive through on the way out;
- Transactions need to be clean, straightforward, simple and uncluttered;

- Don't want to have food and petrol together on the forecourt as food might absorb the petrol fumes;
- With fuel cards - only some things can be paid for using the card (some companies won't pay for food etc);
- Don't want to wait around for petrol because someone is ordering an ice-cream;
- Only offer standard products that people know without seeing.
- Could cause a bad flow rate - would rather have two types of interface on the forecourt, one for petrol and one for other purchases.

In summary, the members of the focus group felt that they would like to see an improved and updated version of forecourt service terminal in local service stations. The group all indicated that they would be willing to buy fuel and any standard items that they didn't feel the need to see before purchase, on the forecourt. The main concern was that the proposed system would cause delays at the pump. The overall feeling amongst the group was that if the system was to be a success in their eyes it would need to make visiting a service station more convenient and time efficient.

4.3 Observational Analysis

Following on from the focus group, a study was made into what customers, at service stations, do while on the forecourt – a current system overview. There are two main current methods to purchase fuel at a service station:

- Paying by card at the pump using an FST, or
- Paying instore.

4.3.1 Paying at the Pump using the Current FST

The flow of messages displayed on the current FST in relation to any user inputs has been compiled through observation into the figure 4.4.

When completing a transaction using one of the current FST models, the user is required to make their purchase in one order:

- Swipe card,
- Select account,
- Enter pin number,
- Enter fuel preset,

- Lift pump nozzle,
- Dispense fuel,
- Replace pump nozzle,
- Remove receipt.

Normal Message Flow for EFTPOS Transaction on Current FST

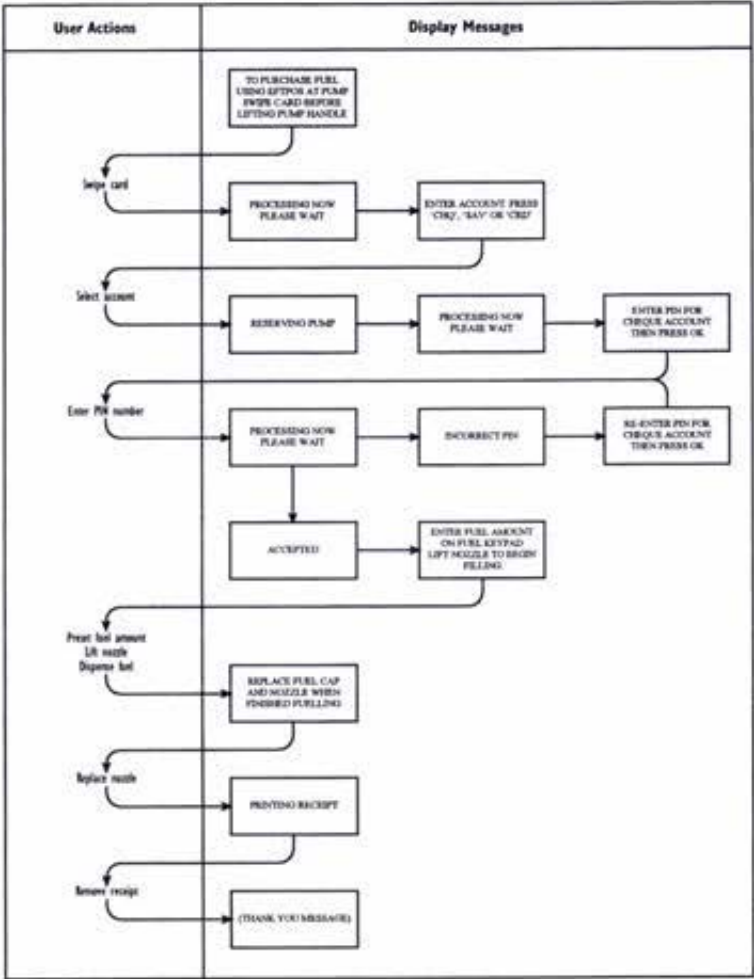


Fig. 4.4: Normal Message Flow for EFTPOS Transaction on Current FST

4.3.2 Paying Instore

One of the objectives for the FST mark 3 was for the system to allow the customer to make purchases and select a method of payment in any logical order. For this reason, paying instore was the more interesting of the two purchase methods. When paying instore the customer can choose how they complete their fuel delivery.

To ascertain the ways in which people dispensed fuel, when unrestricted by an FST, customers coming into a local service station were observed. The time spent parked at the pump and the order in which tasks were performed was noted for each customer. The tasks of interest were:

- Removing and replacing the petrol cap,
- Lifting and replacing the pump nozzle,
- Placing the nozzle in the car,
- Removing the nozzle from the car,
- Entering a preset fuel amount,
- Dispensing fuel.

It was also noted which of the tasks listed above were carried out by the customer and which were carried out by a forecourt attendant.

There were 20 different combinations of the specified tasks that were feasible. The different combinations are displayed in figure 4.6.

During the period of observation, all of the combinations were used. The most commonly observed order is shown in figure 4.5. This order was as follows:

- Drive up to pump
- Remove petrol cap
- Lift nozzle from pump
- Preset fuel amount
- Place nozzle in car
- Dispense fuel
- Remove nozzle from car
- Replace nozzle on pump
- Replace petrol cap
- Pay instore

One potential problem arising from the customer performing their fuel purchase in the most common order is that the nozzle is in the users hand while they make their fuel preset. During the period of observation, the nozzle was occasionally used to press the preset buttons. There is a danger that if the user is holding the nozzle when entering a preset on a touch panel, that they will hit the screen with the pump. This could cause expensive breakages.

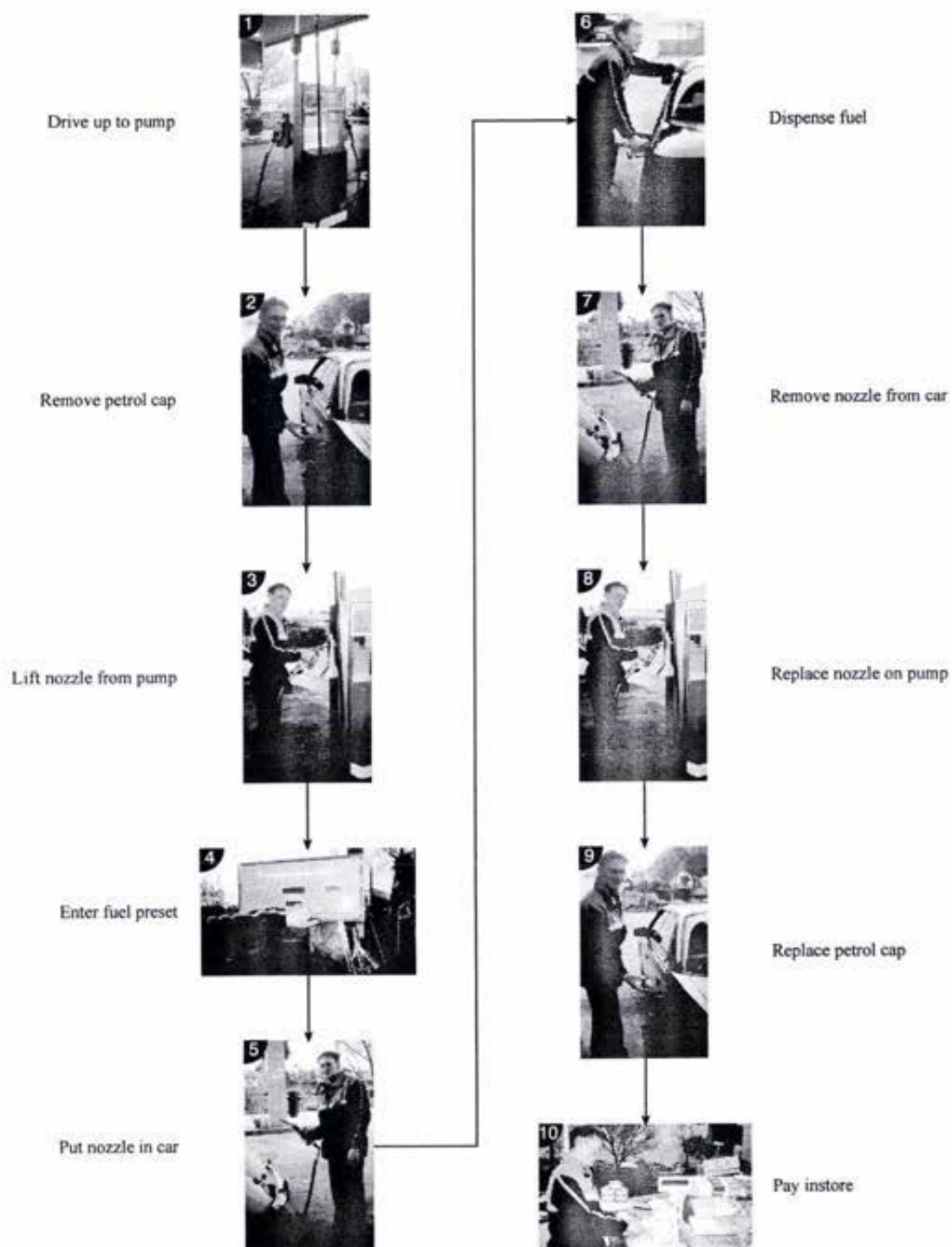


Fig. 4.5: Most commonly observed order used to make a fuel purchase

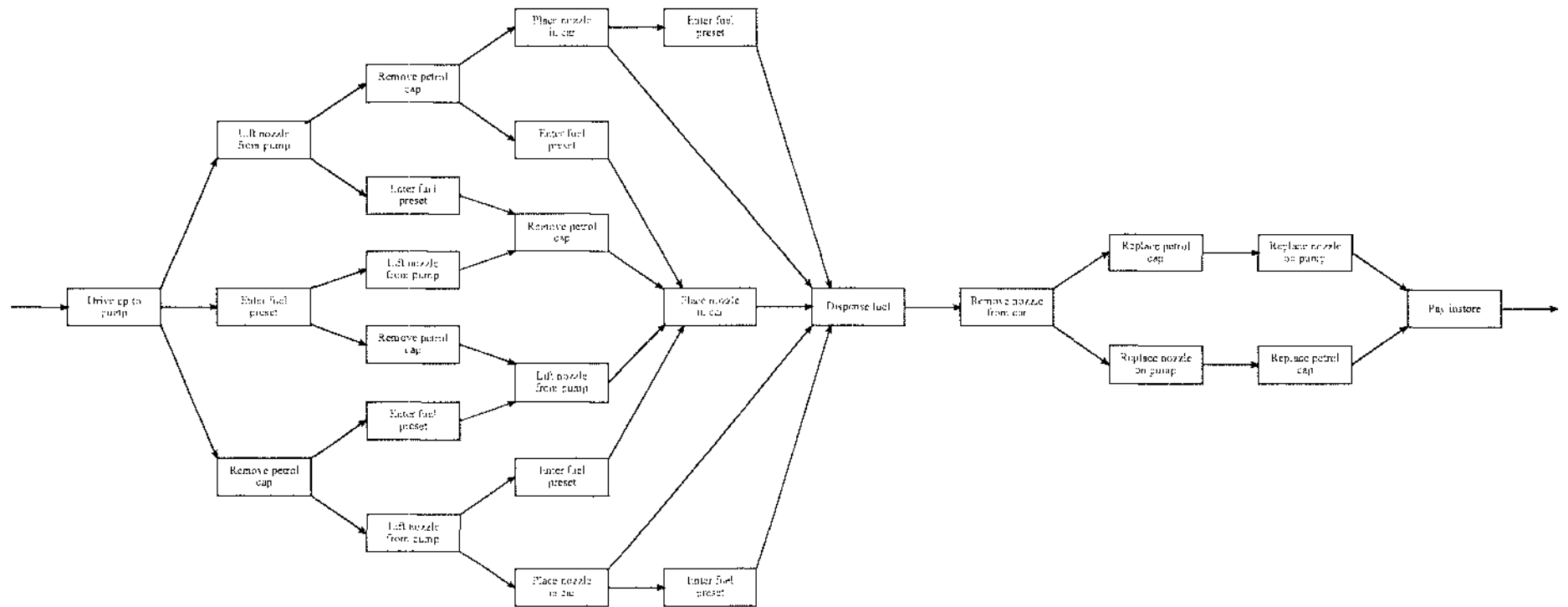


Fig. 4.6: Possible Order of Tasks when Purchasing Fuel

Observations made while at the service station included:

- People asking for a certain amount of petrol and handing the money directly to the attendant (didn't go instore to pay) were stopped at the pump for a much shorter time;
- The time taken to dispense the fuel was less than the average time spent instore;
- Even an attendant used the nozzle of the pump to press the fuel preset buttons;
- About half the customers wanted to have their oil and water checked;
- Most people had their windscreens cleaned by an attendant;
- Items purchased from the store by customers at a pump included:
 - Bread,
 - Milk,
 - Cream,
 - Paper,
 - Chippies,
- Bottles of softdrink.
- Most of the people who filled their own cars did not buy anything apart from the fuel;
- The majority of people filling their own cars were male;
- Most of the people who had an attendant dispense their fuel went instore while the fuel was being poured;
- The average time parked at the pump was about 3.5 minutes.

4.4 Technical Studies

Information providing guidelines on the technical aspects of the project. Information was accumulated, studied, and classified as follows:

4.4.1 Standards and Specifications

Relative standards that need to be considered during the project development include:

- ETSL regulations (ETSL approve electronic banking within New Zealand and Australia);
- Regulations for electronic equipment located on a service station forecourt;
- Ergonomic requirements for visual display terminals;
- Electrical safety standards.

Throughout the duration of the project PEC monitored the relevant standards, as they will later be applying for product approval in the required areas.

4.4.2 Touch Screens

There are seven basic types of touch technology currently available. These are as follows:

- Capacitive overlay,
- Resistive overlay,
- Force vector,
- Guided acoustic wave,
- Scanning infrared,
- Strain gauge,
- Surface acoustic wave.

All types of touch systems are attached to a display unit such as a Cathode Ray Tube (CRT) on a computer monitor or a flat panel Liquid Crystal Display (LCD).

Each type of touch technology has attributes that are desirable for specific applications. Some of these attributes as identified in Carroll Touch (1998) are detailed below:

Capacitive Overlay

- Voltage is applied to the four corners of the screen. Electrodes spread out the voltage creating a uniform voltage field. When a finger touches the screen it covers a few thousand pixels. The electrode field absorbs charge from the finger and identifies centremost point as hotspot;
- Most advanced touch screen technology;
- Offers fastest response time and clearest picture;
- The screen may be gasket sealed to protect from dirt and water;
- Gloves cannot be worn when using this touch technology.

Resistive Overlay

- Screens use a flexible membrane with a coating of transparent metal oxide and a grid of spaces to locate the touch point;
- Works with any stylus;
- Not affected by dirt, dust, water, or light;
- Resistive layers can be damaged with sharp objects;

- Requires repetitive calibration;
- The metal oxide coating and spacers may reduce the picture quality and brightness of the screen image.

Force Vector

- A terminal is placed onto a monitor. This is made up of a top plate resting on three-dimensional springs. Internal sensors measure the distance between the top plate and the base. When the display is touched, the force narrows the distance between the top plate and the base changing the capacitance across the plates and determining the amount of movement in the 'x', 'y', and 'z' directions;
- Not affected by dust and dirt;
- Independent of display type;
- Sensitive to vibration and shock;
- Subject to drift – requires complex calibration;
- Slower response time than other touch technologies.

Scanning Infrared

- Sends infrared beams across the screen in a grid pattern. As the screen is touched the grid is interrupted and that interruption becomes the touch point;
- Tolerant of vibration and shock;
- Not susceptible to scratching or breakages;
- No stylus material limitation;
- If the grid patterns are too large the screen will have many dead spots and precision touch can be difficult;
- Screen may sometimes react before a physical touch is made.

Strain Gauge

- Consists of a CRT mounting shield, a clear glass overlay, and four strain gauge transducers at the four corners to measure, compare, and calculate the touch location;
- Not affected by dust and dirt;
- No stylus limitation;
- Sensitive to vibration and shock;
- Glass overlay can easily be broken;

Surface Acoustic Wave

- Sends acoustic waves across the top surface of the screen;
- The finger absorbs a portion of the wave as it touches the screen and the centre of this touch point becomes the hotspot;
- No drift operation so it does not need to be recalibrated often;

- Must be touched by finger, gloved hand, or soft-tip stylus. Hard objects do not work;
- Not completely scalable;
- Anything on screen such as dirt will interfere with the touch screen by slowing responses.

Guided Acoustic Wave

- Sends acoustic waves through the screen substrate.
- Provides clearer images than surface acoustic wave screens;
- Tolerant of vibration but susceptible to shock;
- Not suitable for outdoor use as it has a low tolerance for surface contamination;
- Glass overlay is easily broken;
- Extraneous movement near the screen surface may be picked up and registered.

PEC identified the guided acoustic wave and scanning infrared touch technologies as being suitable for the project.

Micheal and Miller (www.dcl.vt.edu/~sgm/Report.html) indicate a range of tasks that are, and are not, suitable for touch screens.

Touch screens were identified as being good for the following tasks:

- Pointing,
- Rapid pointing,
- Selecting.

Tasks that are not suitable to be performed using a touch screen include:

- Dragging,
- Tracing,
- Tracking,
- Alphanumeric data entry.

4.4.3 Touch Screen Interface

Target Location

The international standard ISO 9241, titled “Ergonomic requirements for office work with visual display terminals (VDT)s” specifies in part 9 that touch sensitive targets should be below shoulder height and within the reach envelope

of the user. For frequent tasks the location of targets should be within 50cm of the user.

Target Size

ISO 9241, part 9, specifies that the minimum touch sensitive areas for fingers should be at least equal to the 95th percentile male distal joint breadth of digit two. This measurement equates to about 2.4cm x 2.4cm.

A study performed by Micheal and Miller (www.dcl.vt.edu/~sgm/Report.html) determined that target sizes down to 1cm x 1cm were accurate.

The U.S. Military standard MIL-STD-1472C specifies that touch sensitive areas will be within a range of approximately one to two centimetres, with an optimal area of 1.27 cm².

Target Orientation

Micheal and Miller (www.dcl.vt.edu/~sgm/Report.html) indicate that there is a user preference for horizontally-oriented targets, however they concede that in some applications vertically-oriented targets may be necessary or desirable due to space requirements.

Response Time

The response time for a computer is defined by Shneiderman (1992) as being the number of seconds it takes from the moment the user initiates an activity until the computer begins to present results.

Response time guidelines according to Shneiderman (1992):

- Users prefer shorter response times.
- Longer response times (greater than 15 seconds) are disruptive.
- Users tend to change the usage profile in response to the experienced time lapse between activity and result.
- Shorter response times lead to short user think times (think times is the number of seconds which the user thinks before entering the next command).
- A faster pace may increase productivity, but error rates may also increase.

- The ease of error recovery ease and the time it takes to recover the error influence the optimal response time.
- Response time should be appropriate to the task. For example:
 Typing, cursor motion, mouse selection: 50 to 150 milliseconds,
 Common tasks: 2 to 4 seconds,
 Complex tasks: 8 to 12 seconds.
- Users should be advised of long delays.
- Modest variability in response time is acceptable.
- Unexpected delays may be disruptive.
- Empirical tests can help to set suitable response times.

For a touch screen the response time is defined as, the time required for the touch system to locate a touch and transmit the message about touch location to the host system (Carroll Touch, 1998). Factors that influence the response time include:

- Touch system response;
- Host processing speed;
- Access to host electronics and application software.

For capacitive overlay, guided acoustic wave, resistive overlay, scanning infrared, strain gauge, and surface acoustic wave touch systems, touch system response is typically less than 50 milliseconds for a single touch. Force vector touch screens have a typical response time of 150 - 250 milliseconds.

4.4.4 Pump Authorisation

Before a petrol pump can dispense any fuel it needs to be authorised. Authorisation can be given in a number of ways:

Automatic authorisation

- Pumps are able to dispense fuel. Automatic authorisation is often given to pumps on an attended forecourt during normal working hours.

Manual authorisation

- Each pump is told when it can dispense fuel to a customer. Manual authorisation is often used after hours when a forecourt is unmanned.

Card authorisation

- At a truck stop (unmanned station) or when using a current FST model, the pump is authorised by the user swiping their card and entering correct details.

5 Product Specification

The product is a Touch Screen Interface for a Forecourt Service Terminal (FST) to be incorporated into a developing system to facilitate purchases from a service station.

5.1 System Overview

The purpose of this system is to provide a method of payment at a petrol pump for purchases such as fuel, travel related products, car related products, and commodities. The aim of the project is to improve on the current EFTPOS at pump systems in order to give PEC a market advantage over competing fuel pump companies.

The system comprises of the following:

Terminal

- Card reader
- Printer
- LCD screen
- Touch panel
- Internal processor
- Interface
- Mounting

Site controller

Product criteria associated with the listed system components are given below.

5.1.1 Terminal

The terminal will house the Liquid Crystal Display (LCD) screen, touch panel, card reader, printer, and internal processor. It will be mounted in accordance with regulations for electronic equipment within a service station environment.

The operation of the terminal can be separated into six main tasks:

- Payment using a card at the pump;
- Purchasing fuel;
- Purchasing other products or services at the pump;

- Printing a receipt of the purchases;
- Communicating with the site controller;
- Advertising and providing information.

Card Reader

- The unit shall have the ability to recognise and accept both magnetic and smart cards in the form of EFTPOS, credit, fuel or local cards.
- When a card is read, the site controller contacts the bank, via a telecommunication link, to provide authorisation for the use of the card.
- If the customer enters the wrong pin number more than a set number of times the card details will be logged and the user will be barred from completing a transaction at the pump using that card.
- Memory cards must be able to be captured for the duration of the transaction.
- A magnetic card read will either be performed manually with the customer inserting and extracting their card to get a card read, or automatically with a motorised version that captures and reads the card independent of the user.
- The collection of personal details such as pin numbers shall be in accordance with ETSL regulations.

Printer

- At the completion of a transaction the terminal will provide the customer with a receipt detailing their purchases. This receipt can then be used to redeem any other products or services requested during the transaction.

LCD Screen

- It is assumed that the LCD screen will be a 256 colour 640 x 480 pixel 10.7-inch monitor.

Touch Sensitive Panel

- The touch sensitive panel provides a medium for the customer to select and make choices guided by the interface.
- It is assumed that the choice of touch panel will be an infrared screen.

Internal Processor

- The internal processor will store and process some of the information required to run the interface, and will communicate directly with the site controller for additional information and processing.

Interface

- The interface, displayed on a Liquid Crystal Display (LCD) screen with a touch sensitive panel, will lead the consumer through a fuel purchase in a convenient and simple manner, while catering for impulse purchasing of other products and/or services. The interface will be able to be customised for individual service stations both in New Zealand and overseas.
- The computer human interface shall be in accordance with any regulations for touch screen input.
- The contents of the displays within the system shall be presented in a consistent, standardised manner.
- Where possible, standard practices for the positioning of keys shall be used. (ie. number pad, alphanumeric keypad, arrow keys etc.)
- The response time for a mouse click shall be between 50 - 150 milliseconds. Standard tasks shall respond in less than 4 seconds. Where the response time is slower than 2 - 4 seconds, a status indicator shall be used.
- Messages shall be concise while allowing the user to get more information if required. The user must perform an explicit action to make a message disappear.
- Audio feedback shall be provided.
- The layout of the screens shall make sense independently of colour.
- A high contrast between foreground and background colours shall be used.
- Colour connotations shall not be violated. (ie. green for go or O.K., red for stop or something wrong etc.)
- No more than four colours of text, three fonts or four font sizes shall be used.
- Static icons or buttons shall appear in the same place on all screens.
- Where possible, user actions shall be easily reversible.
- Content shall be evenly balanced across the screen.
- At least 25% of the screen shall correspond to white space.
- Not more than two rates of flash coding shall be used. Where one rate is used, flashes will occur at 3-5 per second, and where two rates are used the second shall be less than two flashes per second.
- The interface shall provide a logical flow of information with the emphasis on completing one task before beginning the next.

Mounting

- The mounting will consist of a panel that houses the LCD screen, touch sensitive panel, internal processor, card reader,

and printer. The panel will then be mounted either in a petrol pump, in a wall, or in a freestanding pedestal. The mounting will remain a consistent size, independent of the screen size used.

General

- Purchasing of fuel shall make use of the existing fuel counters to display running totals of the amount dispensed.
- Before fuel can be dispensed the pump must be authorised via the site controller.
- The terminal will allow the customer to preselect an amount of fuel required.
- Purchasing of other products while at the pump will be optional.
- The entire system shall be able to successfully complete a transaction in the event of a power failure.

The type of information stored within the terminal will include:

- Sequence for the collection of personal details such as pin number, odometer reading, and registration number.
- Error messages

5.1.2 Site Controller

The site controller is to keep track of all the terminals within a service station. It provides each terminal with additional information that is not already stored within the internal processor, and communicates directly between the terminal and financial network to process card details.

The type of information stored on the site controller will include:

- Advertising
- Customisable screen details

5.2 Environment

The system is designed for use in an outdoor environment at a service station. For the correct functioning of the unit it is important that:

- The screen is visible under natural lighting conditions,
- The unit is protected from water, dust and fuel contamination,
- The unit is able to work at a range of temperatures and humidities,

- The unit is resistant to vandalism.

5.3 Consumer Profile and Needs

Typical characteristics of the consumer include:

- Drives a car, truck or motorcycle,
- Purchases fuel at a service station,
- Using the fuel pump is only a small part of the customers day, week or month,
- Most, but not necessarily all, customers will have used EFTPOS as a method of payment,
- Most users will not have had much contact with touch screens,
- Some, but not necessarily all, will have experience with the purchasing of products without first seeing the product. (ie drive through restaurants, mail order, vending machines etc.)
- General skill level will vary greatly across the customer group.

Consumer needs from the system include:

- Must be able to be used without any prior learning,
- Where possible, sections of the transaction must be able to be reversed with change of mind,
- Receipt of purchases made.

5.4 Aesthetics, Appearance and Finish

This system is intended for use within a service station situation. The system shall, therefore, be able to fit into the layout and style of the different oil companies.

5.5 Ergonomics

The terminal is intended for use by adults standing at the fuel pump.

5.5.1 Physical

The system shall be designed for adults in accordance with good design practice.

The card reader shall be located to the right hand side of the monitor in either a vertical or horizontal format.

5.5.2 Controls and Display

The controls for the system shall be laid out in hierarchy of their importance and relevance to the user.

Colour shall be used to differentiate controls.

The size of buttons, graphics and text shall be suitable for use by standing adults.

5.6 Manufacturing Facilities

The system will be assembled by PEC (New Zealand) Ltd.

5.7 Maintenance

The terminal shall have a hinged front panel that will allow service station staff access to internal items such as the printer, to allow change of paper etc.

The coding information for EFTPOS transactions is set and maintained by the bank.

5.8 Standards and Specification

The system shall be designed to comply with New Zealand Standards and Specifications. These include electrical safety, touch screen interfaces, service station practices, EFTPOS banking requirements, and telecommunications.

6 Human Interaction and Computer System Action

All of the events that will occur at the Forecourt Service Terminal (FST) can be separated into one of two categories:

- Human interaction
- Computer action

Human interaction may be defined as any communication between the user and the system. Human interactions are independent of the computer actions. Computer actions are carried out by the system and are often unknown to the user. The computer actions are initiated by the human interactions. Examples of both types of action are detailed below:

Human Interaction

- Inserting either a smart card or magnetic stripe card;
- Entering personal details, like PIN numbers, relating to the card inserted;
- Entering a fuel preset;
- Lifting and replacing a pump nozzle;
- Starting and manually stopping a fuel delivery;
- Multiple fuel purchases on one transaction defining the same or different grades of fuel;
- Purchasing other products on the forecourt or instore;
- Removing transaction receipt.

Computer Action

- Card read;
- Telecommunications link to a financial network to check the validity of the card and the personal details entered;
- Controlling the amount and type of purchases depending on the restrictions imposed by the service station or the card used;
- Authorisation of the pump;
- Automatic fuel dispensing cut-off;
- Displaying error messages when required;
- Printing a transaction receipt;
- Advertising.

Defining a possible flow sequence for human interaction and computer action creates a project storyboard.

6.1 Two-Dimensional Flow Chart

The first method used in this project to display a potential storyboard was a standard two-dimensional flow chart. However, the large number of possible options at each level caused the diagram to be extremely confusing and bulky after only a few events.

A few sections taken from the initial flow diagrams are illustrated in figure 6.1.

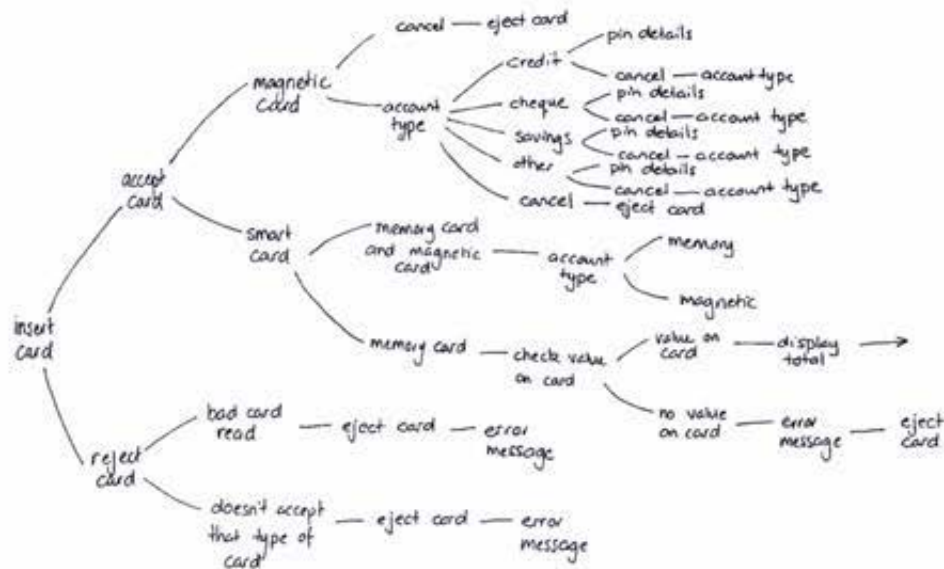


Fig. 6.1a: Computer Actions Following a Card Inserted into the System

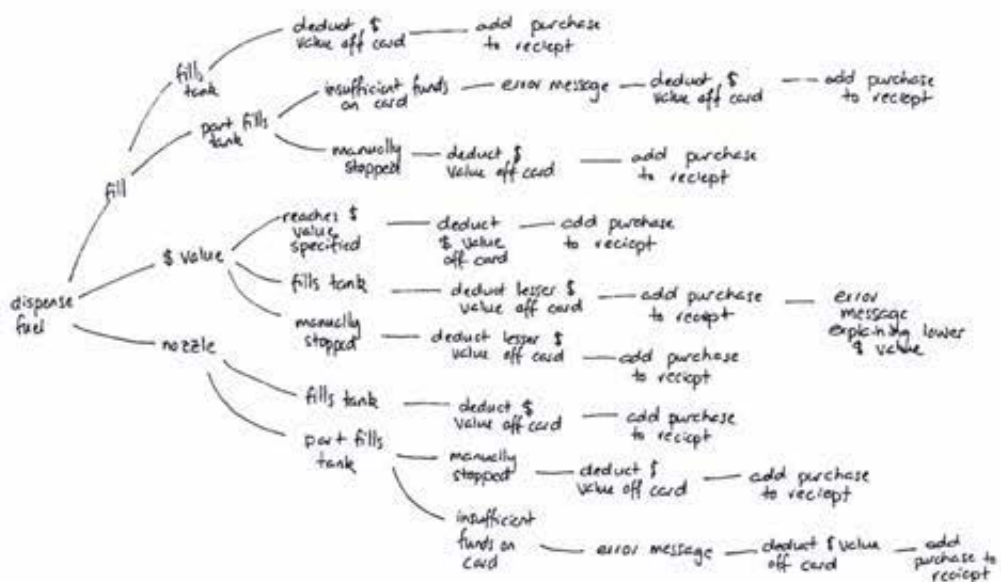


Fig. 6.1b: Computer Actions Resulting from Starting a Fuel Delivery

The two-dimensional storyboard is an essential part of the FST development. Initially, the paper charts were used to define the interface structure and to ensure that the technical content was correct before prototyping.

Eventually the storyboards will be used by other members of the FST development team to assist with the writing of the hardware that will drive the final system. This makes it necessary to develop and display the flow of information and actions in a way that can be understood and used by others. The three-dimensional paper storyboard often also provides a useful tool for this purpose.

6.2 Three-Dimensional Paper Storyboard

In order to create a three-dimensional (3D) chart a system was set up such that each potential interface screen was named and assigned to a separate page.

The 3D storyboard began with the default setting – the advertising screen.

Each of the storyboard pages was divided into six sections. For a sample storyboard page see figure 6.2.

The six sections were as follows:

Previous screens

- This column told you the names of the screens that may have preceded the one referred to on the page.

Screens

- This section consisted of two rectangular boxes representing the screen. The first box contained a list of any active buttons or fields, and the content of any prompts or messages. The second box was designed for use at a later stage in the development to hold sketches of the layout of each screen.
- In some cases actions were separated from the screens in order to make the storyboard easier to follow. If a page was assigned to an action only, these boxes were left empty.

Actions

- This section was separated into three parts, active buttons, external actions, and internal actions. The active buttons are all the buttons on the screen, which have a reaction if they are touched. The external actions are any visible events occurring that were not caused by touching the screen. Internal actions are events that give the user no visible signs to indicate that they are occurring.

Reactions

- The reaction column lists the events that occur when an action is performed

Conditionals

- This column lists anything that the action or reaction is dependent on.

Destination screens

- The final column indicates which screen to go to when an action is performed.

A sample of a storyboard page is shown below:

Previous Screen:	Screen: Pin Number	Reaction:	Conditional:	Destination Screen:
Select account	<div>message asking user to enter a pin number</div> <div><div>1234567890</div><div>clearcancel</div></div> <div>Screen Layout:</div>	<div>Active Buttons:</div> <div>0-9 clear ok cancel</div> <div>External Actions:</div> <div>pick up pump trys to dispense fuel</div> <div>Internal Actions:</div>	<div>logs first number of PIN clears PIN number logs an incorrect PIN exits program</div> <div>register fuel type start dispensing or alert message ask user to enter card details first</div>	<div>Pin 2 Pin Number Incorrect Pin Advertising</div> <div>Pin Number Pin Number Card First</div>

Fig. 6.2: Sample Storyboard Page

This method of storyboarding was extremely good for recording all the details needed to program the interface. However, it was very hard for the uninitiated to navigate through a transaction or to determine whether anything had been left out. Another method of displaying the information was tried to convey details to those not technically involved, so a Macromedia Director storyboard was also prepared for the interface.

6.3 Director Storyboard

The 3D storyboards that had been completed were used to construct a basic prototype using Macromedia Director 6.0. The idea behind this prototype was to provide all of the buttons that would appear on each screen along with buttons to perform external actions, (eg inserting a card), so that a user could check screen content and information flow without becoming lost in a sea of paper. The prototype had very little emphasis on the screen graphics and layout.

This method of displaying the storyboard was unsuccessful. With the storyboard on screen, it looked too much like it was a full interface design attempt. Comments made by people testing the prototype were solely directed to the graphics and buttons, rather than the information and flow.

6.4 Human Interaction Charts and Computer Action Charts

A third paper-based attempt was made to define the information content and flow. By separating the user's actions from the system or computer actions, the storyboard could be simplified.

Overall nine individual charts were constructed (See charts 6.1 – 6.9). The first chart was a Human Interaction Chart.

The Human Interaction Chart (HIC) shows the possible combinations and orders of events that the user can implement when making a fuel purchase while the pump is in attended mode.

In the second chart the computer actions relative to the users actions have been shown on the HIC as dots. The dots are colour coordinated, with each colour representing a series of computer actions.

The final seven diagrams are Computer Action Charts. There is one chart for each of the actions displayed in the HIC. The Computer Action Charts (CAC) show the basic order of actions that are undergone at each stage by the computer. Positions for error messages have been indicated on the charts, however, the content of these messages has not been defined. There may also be more than one error message at each location.

The charts did not include detailed information about the purchasing of any products and services other than fuel, as this content had not clearly been defined at the time of chart construction.

The screen graphics shown in the charts were indicative only as the Graphical User Interface had not at that time been developed.

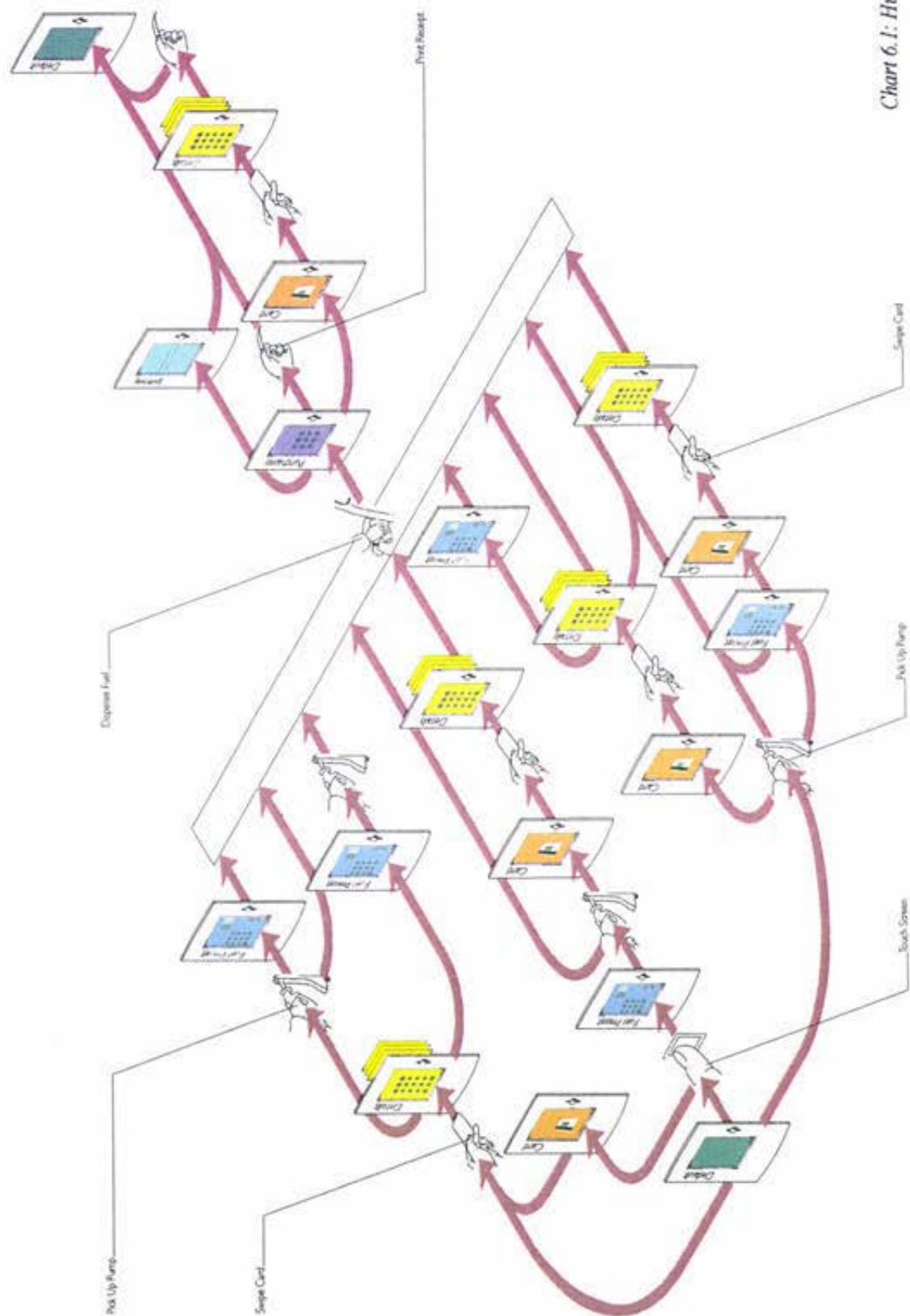


Chart 6.1: Human Interaction Chart

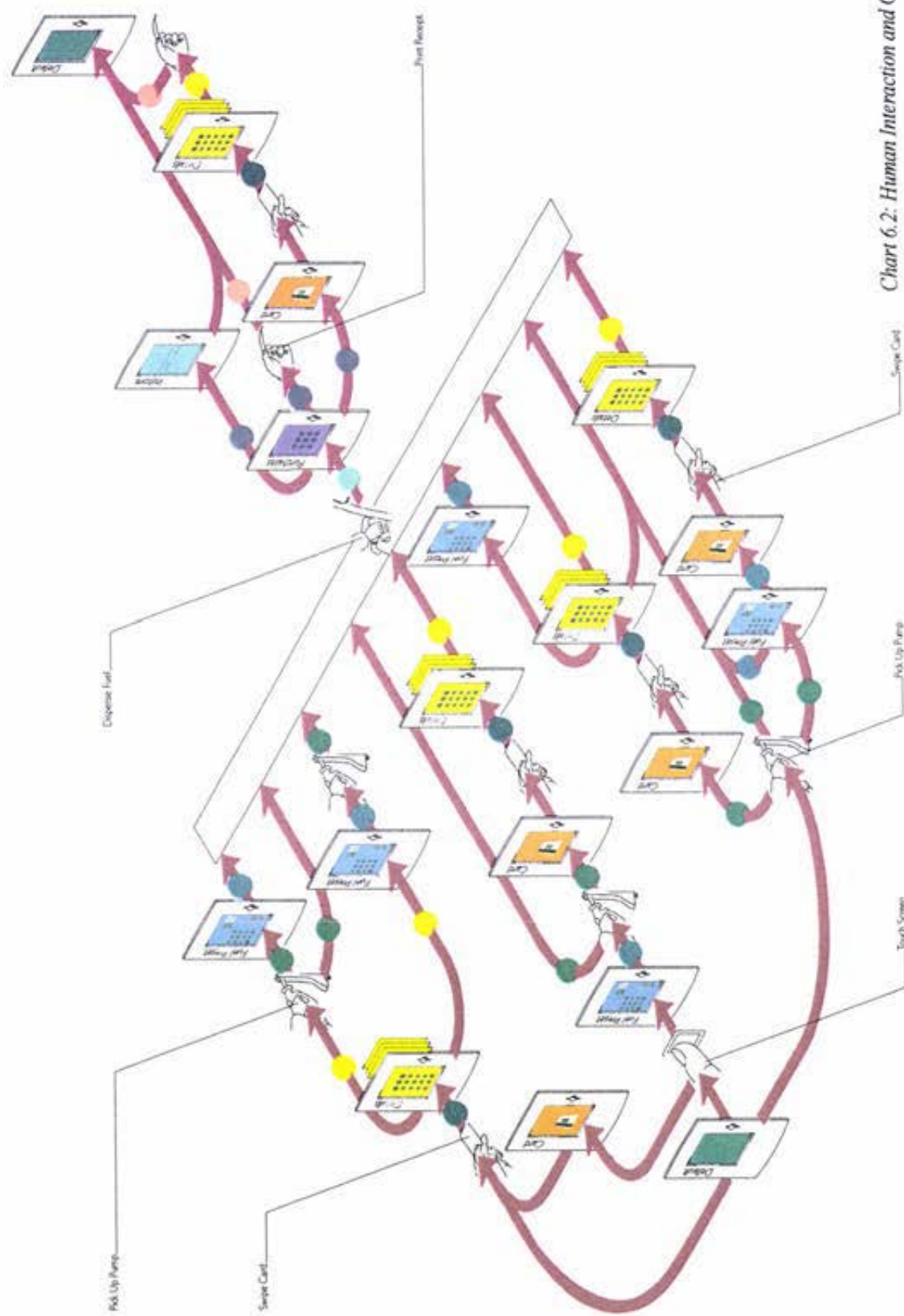


Chart 6.2: Human Interaction and Computer Action Chart

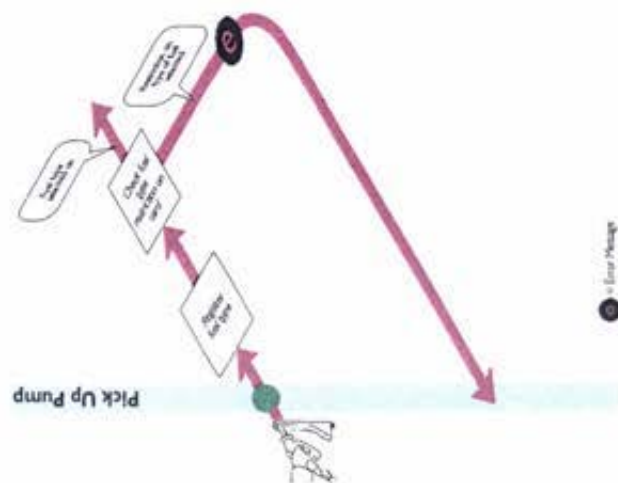


Chart 6.4: Computer Action Chart - Pick up Pump

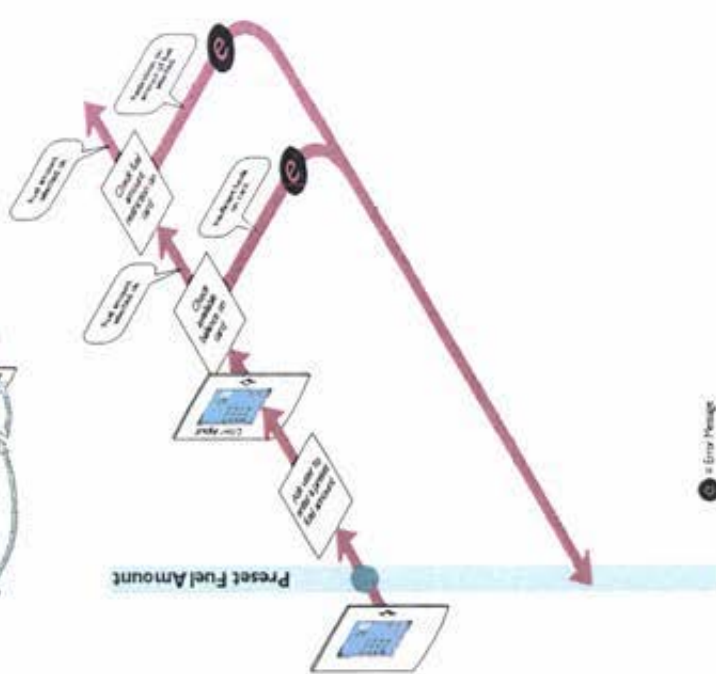
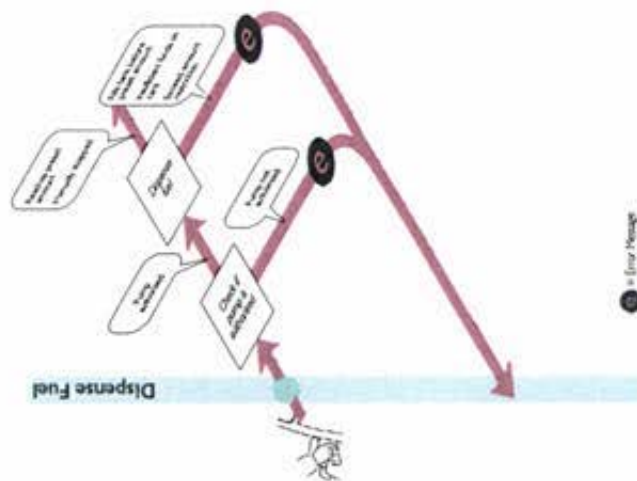
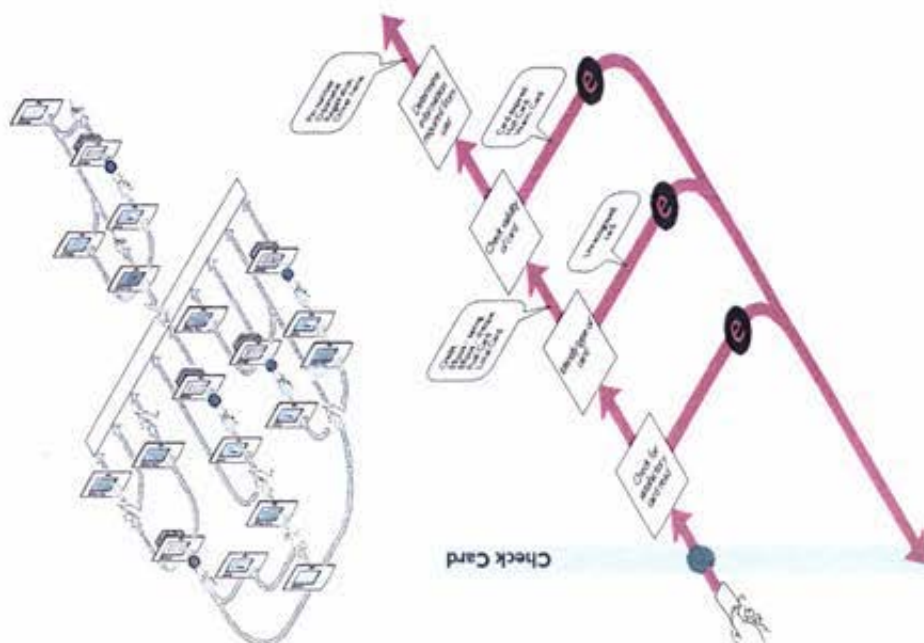


Chart 6.3: Computer Action Chart - Preset Fuel Amount



E = Error Message

Chart 6.5: Computer Action Chart - Dispense Fuel



E = Error Message

Chart 6.6: Computer Action Chart - Check Card

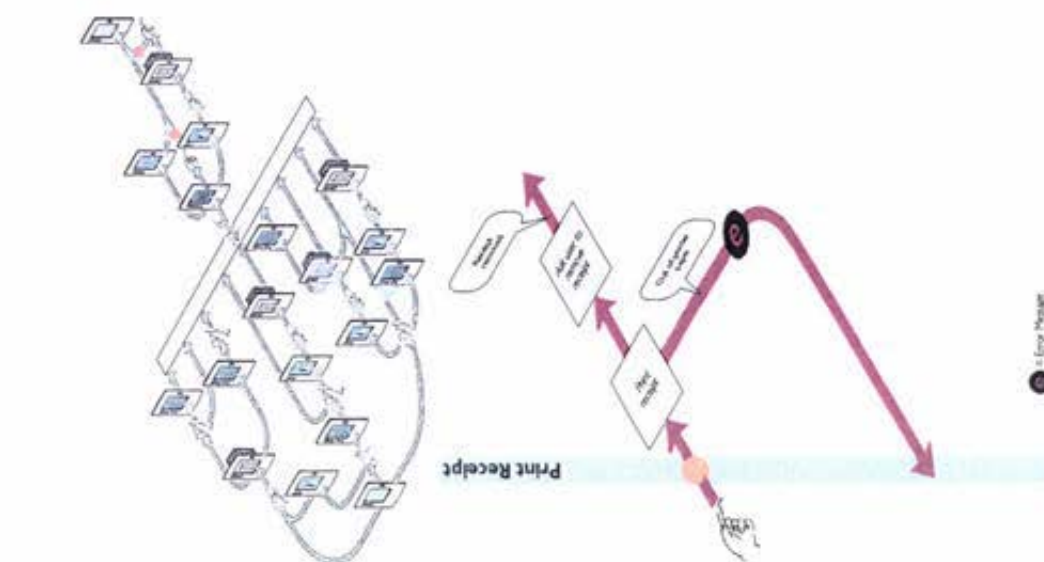


Chart 6.8: Computer Action Chart - Additional Purchases

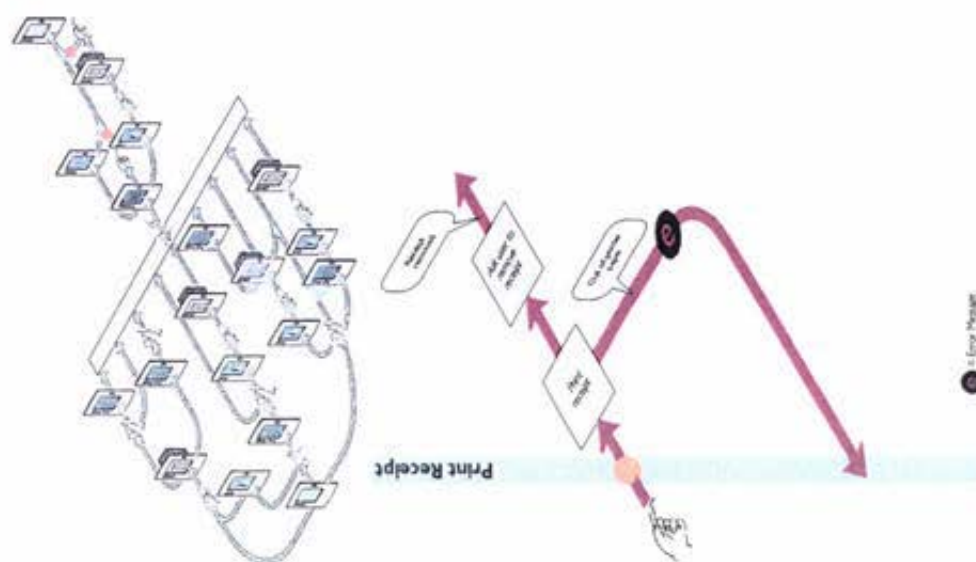


Chart 6.9: Computer Action Chart - Print Receipt

7 Development of the Graphical User Interface

The Graphical User Interface (GUI) has been defined by Hix and Hartson (1993) as any user interaction that has windows, buttons, boxes, icons, “and so on”, p85.

7.1 Concept Development

The graphical user interface for the Forecourt Service Terminal (FST) will by specification provide a medium with which consumers can do the following:

- Make purchases;
- Receive information;
- Enter information.

7.1.1 Identify Range of Functions

Preliminary data gathering yielded further details of required function that could be grouped as follows:

Purchases

- Fuel:
 - 91 Unleaded,
 - 96 Unleaded,
 - Diesel,
 - LPG,
 - CNG.
- Products available on the forecourt:
 - Car wash,
 - Oil,
 - Fuel additives (ie. Valvemaster).
- Products available instore:
 - Confectionary,
 - Snacks,
 - Beverages...

Receipt of Information

- Instructions;
- Fuel grades and prices available at the pump;
- Counters displaying dollar and litre values of a fuel purchase;
- Purchases made at the FST;
- Help.

Information Entry

- Fuel preset;
- Card related personal details (ie. PIN number);
- Selection of other purchases.

7.1.2 Preliminary Function Screens

The GUI content detailed above was divided into the following five screen sections:

Fuel purchases

- Entering fuel preset;
- Information relating to the pricing and grades of fuel.

Car related purchases

- Car wash;
- Oil;
- Fuel additives.

Other purchases

- Snacks;
- Confectionary;
- Beverages...

Payment details

- Smart or magnetic card insertion;
- Entry of personal details;
- Pay instore.

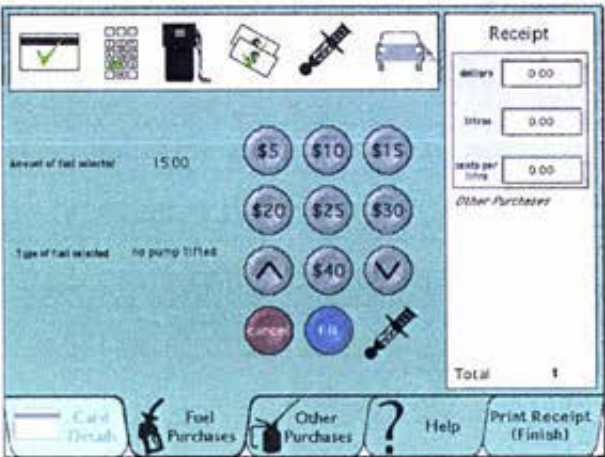
Other Information

- Instructions;
- Fuel counters;
- List of purchases;
- Help.

7.1.3 Prototyping and Responding to Initial Consumer Opinion

Macromedia Director 6.0 (an authoring tool for multimedia productions) was used to prototype the graphical user interface.

The first prototypes contained functions to simulate making a fuel purchase and paying using an EFTPOS card. These are the functions that are available on current FST models in New Zealand.



The division of screens was made using 'tab' dividers. Tabs are currently used within a range of computer programs to enable the user to navigate through sections of information.

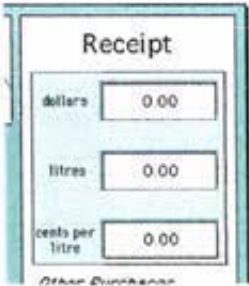


With a touch screen, the consumers felt they would rather have selectable items displayed as buttons. This would help to indicate which items could be pressed.

A receipt detailing purchases made was displayed constantly on screen.



Receipt



Location of fuel counter

The receipt was separated into two section, fuel purchases and other purchase, to aid the user with finding their purchases. The purchase total was displayed at the base of the receipt. When in the fuel purchasing section, a fuel counter was displayed over the fuel purchases section of the receipt.

Initially the customer was asked to select where they would like to pay for their purchases, either at the pump or instore.



This selection process was a redundant step as the user should be able to indicate if they wish to pay at the pump by inserting a card at some point during the transaction.

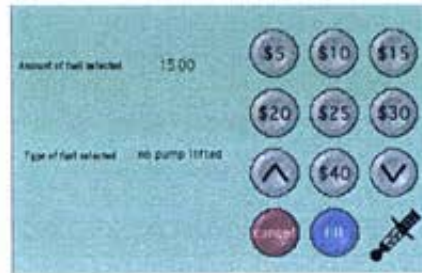
A boxed section containing icons representing tasks to be completed was displayed in the upper left-hand corner of the screen.



The 'task list' showed the user the following information:

- Completed tasks – represented by placing a tick over the icon,
- Available tasks – represented by a black icon,
- Unavailable tasks – represented by a grey icon.

The fuel purchases screen contained a selection of buttons containing pre-defined preset values. Information relating to the type of fuel selected and the preset value was displayed to the right of the buttons.

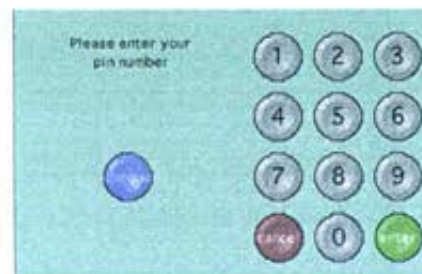


Fuel preset

Screens accepting card-related details displayed buttons for selecting an account type along with numerical buttons for PIN entry.



Select account



Enter PIN number

When an account type was required from the user, the numbered buttons were displayed in a lighter grey and were inactive. Once an account had been selected the numbered buttons were made active and the account buttons inactive.

7.1.4 Identification of Areas for Further Development

Overall the initial design was found to have many inadequacies. Some of these are listed below:

- If the fuel counter on the interface is to replace the fuel counter currently available in the pump head, the counter must be visible at all times;
- The receipt, appearing on the screen at all times, consumes a large proportion of the available real estate;
- The meaning of the icons on the 'task list' were not obvious enough;

- The task list did not aid the user with keeping track of their transaction;
- The tabs used to navigate between the screen types were not sufficiently obvious;
- Icons that could be selected needed to look as though they could be pressed;
- Buttons in the card details and fuel preset screens were too small;
- The information on screen at all times needed to be organised in a better way so as to maximise the space remaining for items displayed temporarily;
- The text instructions needed to be more comprehensive.

At this point the first real break through in the design structure of the interface was made. It was decided to separate the screen into two parts. A 'static screen', and a 'dynamic screen'. The static screen would contain all the buttons and information that was shown on the interface at all times, and the dynamic screen would show buttons and information relevant to what the user was doing at the time.

Some of the concepts generated to divide the screen into dynamic and static sections are shown in figure 7.1.

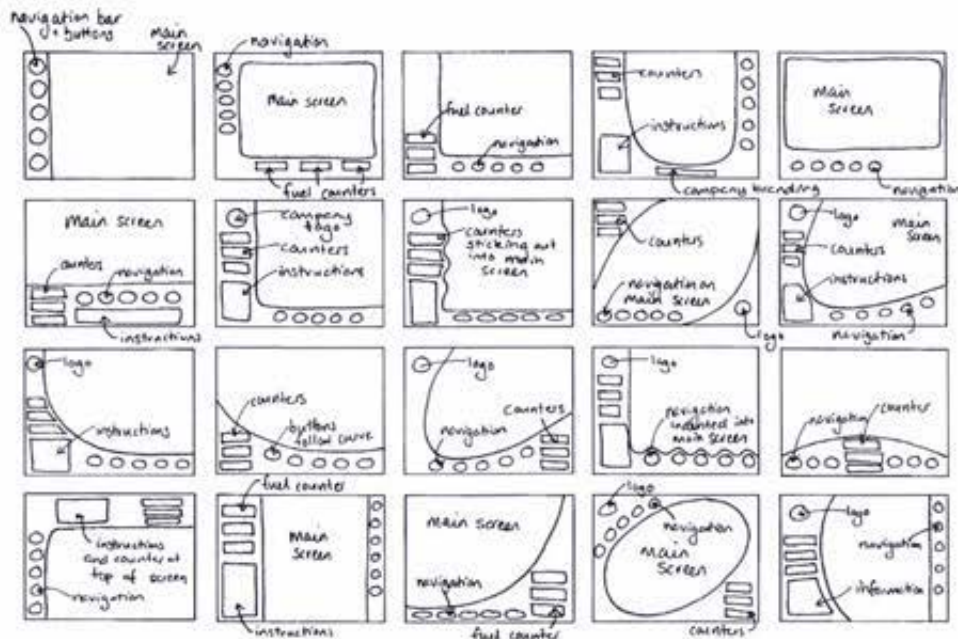


Fig. 7.1: Selection of concepts for dividing the interface into static and dynamic parts

7.2 Detail Development

Initially the dynamic screen was drawn as a rectangle in the top left-hand corner of the interface, and the static screen in an 'L' shape around the dynamic section. The interface was divided in this way to aid in the final programming of the system, as pictures displayed on the LCD screen are defined and drawn with their rectangular boundary.



This design restriction was later overcome and the square interface design gave way to a more curved split between the two screen sections.



The later curved design was described as being more 'friendly' and 'modern' by those reviewing the interfaces, and was named as the preferred layout.

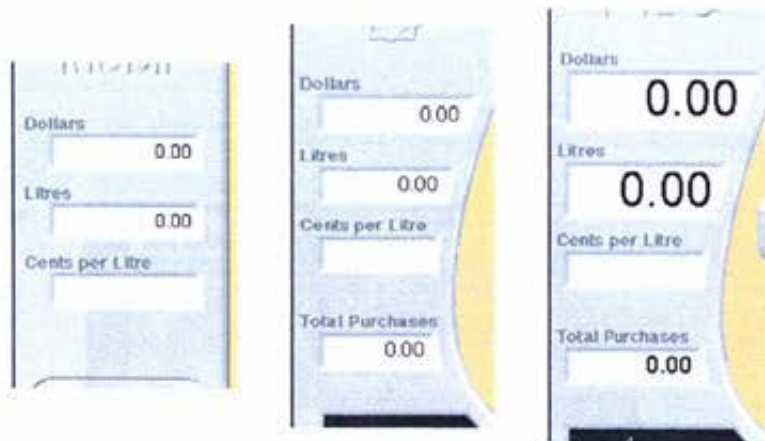
7.2.1 The Static Screen

The static screen contains all the information that is available to the user throughout their transaction. This information includes:

- The fuel company logo or branding;
- A fuel counter showing the amount of fuel purchased in both dollars and litres;
- The cents per litre value of the fuel grade selected;
- An instruction box;
- Navigation buttons which allow the user to select which dynamic screen they view at any one time;
- A completion button that allows the user to finalise their transaction at the pump.

Over a six-month period the design underwent several iterations to the individual aspects of the static screen. These iterations are discussed below.

The Counters



Version 1

Version 2

Version 3

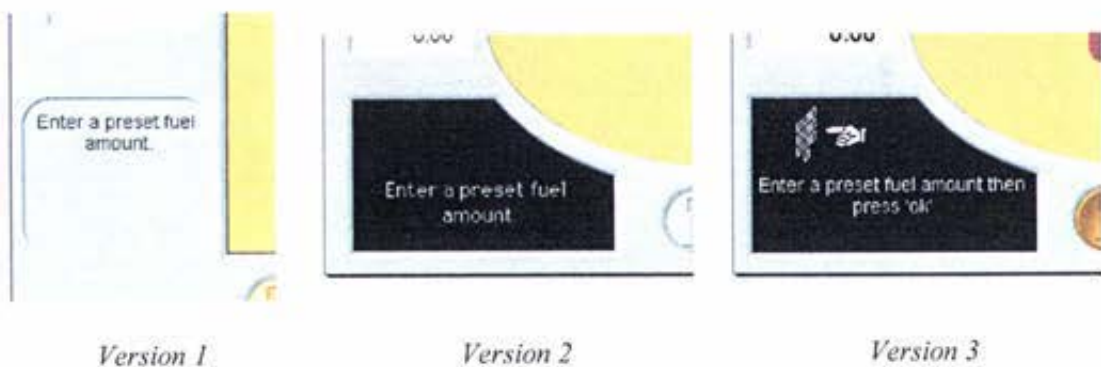
In the first design the counter section contained information relating to the dollar value of fuel purchased, the number of litres of fuel purchased, and the price per litre of fuel purchased.

In the next iteration of the design a fourth value was added to the counter. This value shows the total purchases made by the user. As the FST mark 3 differs from other systems by allowing the purchase of other products at the pump, it was felt that the fourth total was required to reflect this design change. The single total was also seen as a compact way of giving the user information

about the total items purchased. Providing the customer with an item by item list of all the purchases made during their transaction was too demanding on screen real estate.

The other major change made to the counter section was the increase in size of the dollar and litre totals. These totals were increased in size to meet pump standards requiring the characters to be displayed at a size no less than 10mm high.

The Instruction Box

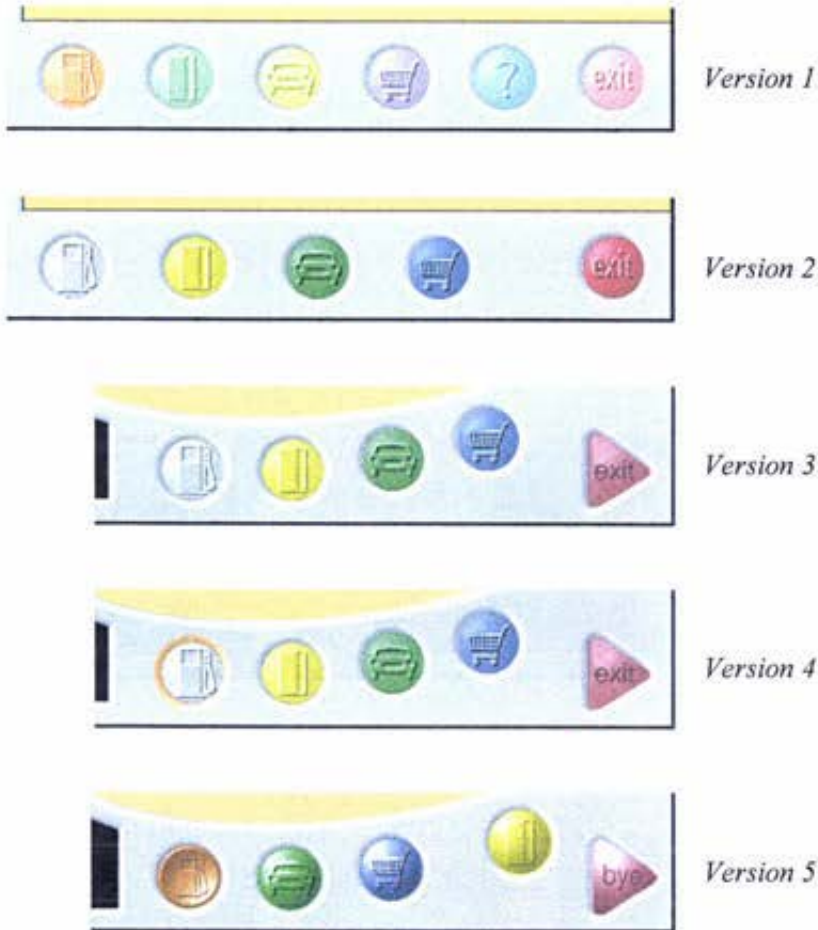


The instruction box was designed to give the user a place to look where they would know that they could always find guidance on what to do next. In the first version of the static screen it consisted of an indented grey box containing black text instructions. This format was changed in the second iteration of design to have a black backing with white text. The background colour change was made to make the instruction box stand out from the other displays on the static screen. The grey box was not bold enough to catch the eye of the customer using the interface and hence was frequently overlooked.

The third version increased the size of the instruction box to allow the inclusion of black and white animations. The animations served the double purpose of drawing the users eye towards the movement and hence towards the instructions while also providing a visual guide on what to do. The wording of the instructions was also changed in this modification.

In the later versions of the interface the instruction box was used as a means to display a receipt of the users purchases. Pressing the instruction box would either show or hide a copy of the receipt on the dynamic screen.

The Navigation Buttons



The navigational buttons are used to move between the dynamic screens. Each of these buttons was assigned a colour. The colour of the button corresponding to the background colour of the related dynamic screens. The finalise transaction button was assigned the colour 'red', as red is associated with stopping. In the first iteration there were buttons for the following dynamic screens:

- Fuel preset;
- Card details;
- Car related purchases;
- Other purchases;
- Help;
- Complete transaction.

The help button was removed from subsequent versions as it was felt that the help did not perform the same kind of function as the remaining five buttons.

The help function would provide guidance relative to the area the user was in, where as the other navigational buttons changed the focal area. It was decided that when a help function was implemented into the design, the access would be through the individual dynamic screens. The help function is not going to be written into the system until the other aspects of the interface have been developed and tested. This will allow the help to be tailored towards the areas of the system where users required the extra guidance.

The shape of the complete transaction button was changed between the first and last versions. Completing the transaction differed from the other navigational buttons in that it was not designed to be toggled between. Once this button was pressed the transaction would be finalised. To reflect the different action of this button it was drawn as a different shape. A triangular shape pointing out of the interface was chosen.

The text displayed on the complete transaction button changed many times during the initial interface design. The first iterations used the word 'exit'. This caused some confusion amongst computer users who thought that pressing 'exit' would shut the program down. The wording was changed to 'finish'. This in turn caused different problems. Users began to press 'finish' when they had finished with the dynamic screen section they were looking at. The wording was changed for a third time to read 'bye'. Either the meaning of 'bye' or 'buy' would be applicable to the button.

After the first version the colours assigned to each of the buttons was made brighter to help the buttons stand out against the grey background.

The appearance of the button corresponding to the dynamic screen section visible was altered to help aid the user with linking the buttons to the dynamic screens. The first method tried was to darken the colour of the selected button. This did not work at all. As all the navigation buttons were different colours, there was nothing to compare the darkened colour with that would indicate a different state. Instead the button was greyed out when its section was in use. This caused confusion amongst the interface testers who thought that a greyed button meant that it could not be pressed. While the fact that the button could not be pressed was true, the user was not making the connection between the button and the dynamic screen. A second variation was experimented with. The

indented ring around the greyed button was given the colourings of the dynamic screen section. Users noticed that the selected button was different to the other buttons, but the appropriate connection between the button and dynamic screen was not made by all. A third variation was tried. The selected button was drawn indented and left with its original colourings. This combination was the most successful. Users associated the indented button with something that was already pressed and therefore understood why no further actions were made by the system if they tried to press the button again. The colour association with the dynamic screen was made by most users due to the colour remaining in the button.

Another limiting aspect of the interface shown on the navigational buttons is when the user cannot access the section of the system represented by the button. This situation arises from a number of situations. One of the most common would be that once a user has inserted their card and entered their card details, the card section of the interface cannot be used again. The other main situation occurs when the card used (ie fuel card) has a restriction of the type of products that can be purchased.



Version 1



Version 2

Two possible solutions to display non-accessible area of the interface were investigated. The first version placed either a tick or a cross over the button depending on whether the area had been completed or could not be accessed because of a restriction. In later versions, buttons that could not be pressed were displayed in grey. This decision was made following the responses to the way the navigational buttons were displayed as being selected. Users associated a greyed button as something that could not be pressed.

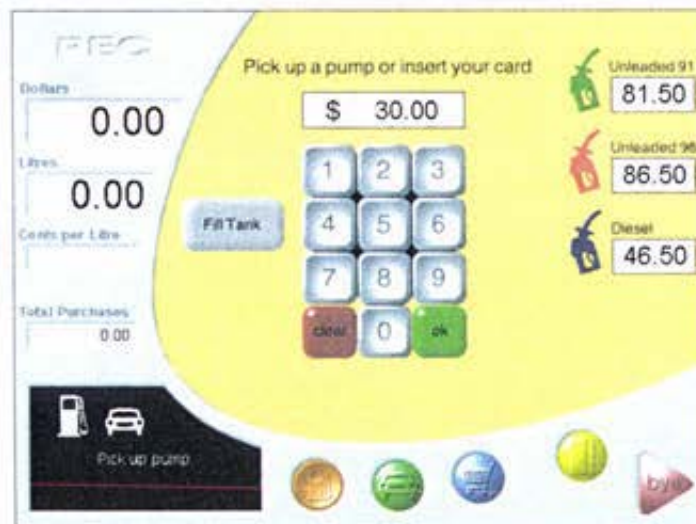
7.2.2 Dynamic Screens

There are five different sections of dynamic screens. These sections correspond to the five navigation buttons on the static screen:

- Fuel preset
- Car related purchases
- Other purchases
- Method of payment
- End transaction

The buttons appearing on the dynamic screen are all raised from the background. This helps to differentiate the dynamic screens from the static screen where all the buttons and information boxes are indented. Two levels are created, with the background of the static screen appearing to be raised above the background of the dynamic screens.

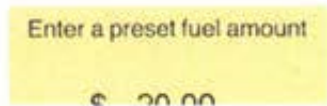
Fuel Preset



The fuel preset screen contains the following buttons and information:

- Instructions;
- 0-9 keys;
- OK and clear buttons;
- Fill preset button;
- Fuel grades and prices available at pump;
- Preset selected.

Instructions



Version 2

In the first iterations of the interface all instructions were displayed in the instruction box on the static screen. Having all instructions in a separate location to the data entry broke the users flow of concentration. In subsequent versions of the interface, a cut down version of the instructions displayed in the static screen was also displayed near the top of the dynamic screen.

Keypad



Version 1



Version 2



Version 3

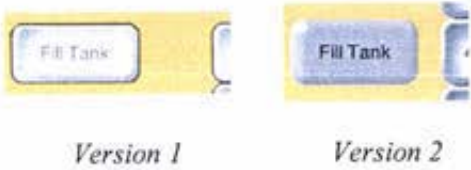
The keypad followed the layout and colour scheme used on the existing keypads available on the pump. The buttons were designed to look like keyboard buttons, with the 'ok' and 'clear' buttons in green and red respectively.

The key size in the first version was found to be too small. In the second design iteration the button sizes were increased. A change was made to the style of the 'ok' and 'clear' buttons. The shape of the buttons was altered to make them stand out more from the 0-9 keys. The triangular shaped buttons were more visible. However, when the buttons were made large enough to be accurately pressed, the layout of the keypad was no longer tidy and compact.

A third modification was made to the two coloured buttons. The buttons were returned to their original square shape with the style of button altered to gain

the desired ‘different’ effect. The colouring of all the buttons was brightened to lift them off the background and to make them more visible under bright light.

Fill Preset



A petrol pump does not require a ‘fill’ preset button. Placing a pump nozzle in the car and starting filling does the same thing as selecting a ‘fill’ preset. When a cars tank is full, the pump will stop dispensing fuel. However, customers are used to being able to tell the petrol pump that they would like to fill their car. Hence a ‘fill’ button was also included in the interface design.

Initially the ‘fill’ button was in the same style as the 0-9 keys. In later versions it was changed to match the style of the ‘ok’ and ‘clear’ buttons. The style of the button was changed to reflect the fact that the ‘fill’ command had a different effect than the 0-9 key commands. When entering a preset amount from the keypad, pressing ‘ok’ logs the preset. However, the ‘fill’ command automatically logs the request without needing to press ‘ok’. The colour of the ‘fill’ button was left grey to indicate that it had the same purpose, to set a preset fuel amount, as the keypad keys.

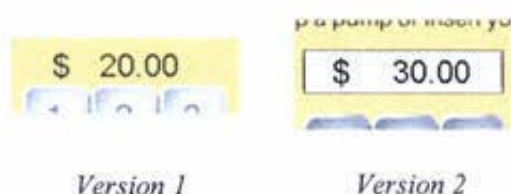
Fuel Grades and Prices



Version 2

In the later versions of the interface information relating to the grades of fuel available at the pump and the prices per litres for each of these grades was displayed. As it is possible that the FST may replace a petrol pump head, the interface must be able to display all the information currently required on a pump head. Standards require fuel pricing information to be available at the pump.

Selected Preset



When a preset fuel amount has been entered, the value is displayed above the keypad. In the initial versions of the interface nothing was displayed on the screen until the customer entered information using the on-screen buttons. It was not clear to the users what effect pressing the buttons would have on the interface. Between the first and last versions of the interface a box was added to surround the entered preset. The white box was visible at all times, indicating to the user where information would be displayed when entered. The white text box has been used throughout the dynamic screens to indicate to the user when they are able to enter information and where the information they enter will be displayed.

Card Details





The card screens are designed to allow the user to enter information in three different forms:

- Selecting an account type from a range of buttons;
- Entering numerical information such as PIN numbers and odometer readings;
- Entering alphanumerical information such as registration numbers and driver names.

When the customer enters the card section of the dynamic screens they are asked to insert a card or press a button indicating they would like to pay instore. If the user inserts a card they are then asked to enter relevant card details. The card details are then processed and access to use the card is sort from the bank. The card will then be ejected (Some cards need to be captured for the entire transaction, this type of card would be ejected after the transaction had been finalised).

The card details screens contains the following buttons and information:

- Instructions;
- Account type buttons;
- Numerical keypad;
- Alphanumeric keypad;
- OK and clear buttons;
- Pay instore button;
- Box for displaying information entered.

Instructions

The instructions in the card details section follow the same guidelines as the fuel preset section.

When the user has entered all the necessary information, the bank is contacted. During the wait while bank clearance is attained a message is displayed on the interface screen.



Version 1

Verifying card details
- Please wait

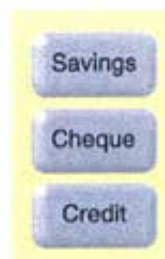
Version 2

In the first version a watch was displayed on the screen to indicate to the user that something was happening. An explanation of the delay was given in the instruction box on the static screen. The users' indicated that they would prefer to have a message explaining the delay on the dynamic screen. In the following iterations of the design, the watch icon was replaced by text.

Account Type



Version 1



Version 2

The account type buttons in the first version were displayed next to a greyed out numerical keypad. Once an account type had been selected the account type buttons became greyed out and the numerical keypad became active. The later versions displayed the account buttons on their own, followed by the keypad beside the button of the account type selected.

Initially the account buttons were displayed in the keyboard style, but the style was changed to mirror the change in the 'fill tank' button on the preset screens.

Numerical Keypad



Version 1

Version 2

Version 3

The numerical keypad, along with the 'ok' and 'clear' buttons, in the card details section is identical to the keypad in the fuel preset section. The two keypads are also located in the same place on the screen. This gives the user some continuity.

Alphanumeric Keypad



Version 1

Version 2

A QWERTY keyboard layout was used as opposed to the alphabetically ordered keys on the current FST. Alphabetically ordered keys compact into a

smaller area than the standard keyboard layout. However, it was felt that using the keyboard layout would help to aid the users to locate the keys faster.

The buttons are displayed in the same style as the numerical keypad.

Pay Instore

In an attended service station the FST will allow customers to make their purchase at the pump and then pay instore. When the FST is in this mode a button asking the user if they would like to pay instore is displayed at the same time as the insert card message. If the 'pay instore' button is selected the system will not ask the user to insert a card again. However, the user may change their mind and insert a card at a later stage if they wish.

Information Boxes

Information such as PIN numbers, odometer readings, registration numbers, and driver names that are entered by the user are displayed on the screen in the same way as a fuel preset.

To ensure that PIN numbers are securely entered into the system the keypad button does not visually respond to a touch, and each digit of the PIN number is displayed on screen as '*'.

Other Purchases





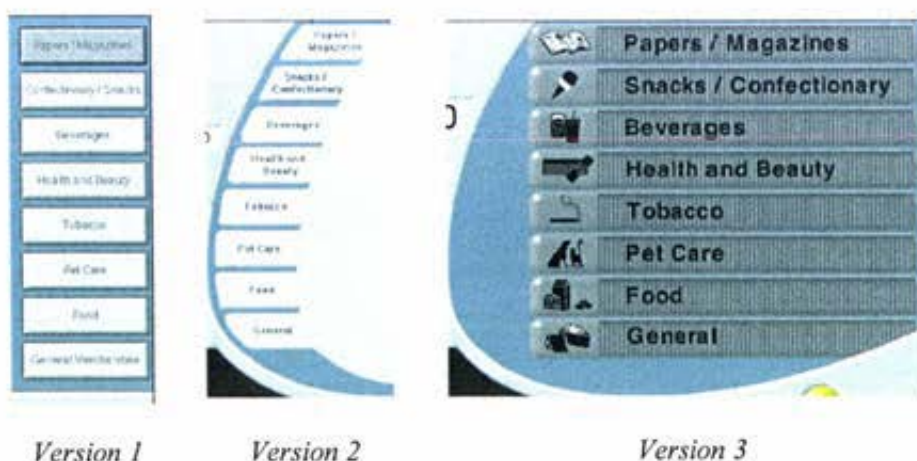
Other purchases refer to any items available at the FST with the exception of fuel. The static screen separates the other purchases into two distinct sections, car related purchases and non-car related purchases. For the purpose of development these two sections were treated as one.

Information presented on these screens can be broken into the following forms:

- Menu selection buttons;
- Individual product buttons.

The development of the other product purchasing is detailed below for the non-car related products. A similar development process was followed for the car related products.

Menu Selection (Version 1 - 3)



The types of purchases were divided into eight categories based on the supermarket division of products. Initially each of the categories was assigned a

button down the left-hand side of the dynamic screen. Products within a category would be displayed on the right-hand side of the dynamic screen when their category was selected. It was decided that there needed to be a more visible division between the category button and the product buttons to help user make the link between product and category.

Iteration two made the category buttons into tabs. The category selected was darkened to match the grey used behind the product buttons. Tabs are used regularly in computer programs to navigate between sections of information. It was hoped that this connection might assist the user. However, some of the users testing the interface felt that the tabs did not look like buttons, and hence were not sure if they could press them.

Version three provided the user with a full screen menu, from which one of the categories could be selected to display the associated products. The eight categories were drawn as rectangular buttons. A representative picture for the category was displayed on the left-hand side of each button. When the user selected a category, the related product buttons were displayed within a box covering the category titles. The category pictures remained visible allowing the user to toggle between product screens. Initially some confusion was caused due to the category titles being hidden. Displaying the selected title within the associated products area solved this. A 'menu' button was also provided to allow the user to return to the main category selection screen.

Product Selection (Version 1 – 3)



Version 2



Version 3

The individual products that can be purchased from an FST will vary between service stations. It is therefore necessary to allow the service station to customise the products available on their interfaces.

In the first versions the individual items that could be purchased were displayed using pictures of the product. The appropriate product pictures would be called from a database and displayed on the interface. Two main problems arose from this format. The first problem was that the items were not displayed as buttons and hence users were not sure how to select the item. This problem was easily rectified in the later versions by placing the picture on top of a button icon.

The second problem with screen space arose. The number of product types that could potentially be available at the FST was huge, and most of these products had a combination of different sizes, flavours and brands. To display all of the products would take up more screen space than was available.

A third tier was added to the product interface. The product buttons in each category were reserved for a single type of item such as chocolate. After pressing the product button relating to the type of item the user wanted to buy, a further screen was displayed with the combinations of size, flavour and brand for that product type.



Version 3

A matrix of buttons was displayed. Each button corresponding to a different combination of size, flavour and brand. When a button was pressed by the user, the '0' was replaced by a '1'. If the user pressed this button again a '2' would then be shown.

Another feature, a switch, was added to the screen. The switch had two possible states, adding and deleting. When the switch was set to the '+' side, any button pressed added one of that item to the customers shopping list. However, when the switch was set to '-', a button press caused one of that item to be deleted from the purchase list. This allowed the user to correct purchasing errors. The 'clear' button would delete all purchases made in the product type category displayed. The user presses the 'ok' button to return to the product category screen.

Menu Selection (Version 4 – 6)



Version 4



Version 5



Version 6

The sheer numbers of items that can potentially be sold at the FST are huge. This caused problems with the user not being able to find the item they wished to purchase amongst the numerous products available.

It was necessary to consider how best to deliver the ordered items to the customer. If the customer needed to go instore to collect their items, the general feeling from the focus group was that they would also pay instore.

The later versions of the non-car related product screens were designed to be used with automatic vending machines located near the pump. The FST will be able to link directly to the machines to dispense the items ordered by the user.

Instead of the eight product categories used in the earlier versions, products were divided depending on which vending machine they appeared in. Buttons

containing pictures of each of the vending machines were used to allow the customer to toggle between product screens.

The vending machine buttons were placed along the top of the screen to maximise the area available for the individual product buttons.

The way in which the selected vending machine button was displayed was investigated. Initially the button was darkened. This did not differentiate the activated button sufficiently. The next version removed the bottom icon from behind the vending machine and placed an arrow at the base of the picture pointing towards the product buttons. Users testing the interface preferred to have the button remain behind the picture, as some did not realise that icon without the button was in fact one of the categories. The third iteration replaced an extended button under the vending machine icon and arrow. This was the preferred combination.

Product Selection (Version 4 – 6)



Version 4



Version 5



Version 6

The screen allowed the display of up to eight individual products. It was discovered that users had problems locating items when they were faced with a large number of buttons. Each product button displayed the following information:

- Picture representing the product;
- Size of product (ie 40g, or 355ml)
- Price per item;
- Quantity ordered by the customer.

The size, price, and icon for each product would be called from the service station's database. This means that any product or pricing changes would be automatically implemented by the interface.

The switch function introduced in the third version was also used in the later version to toggle between adding and deleting products. To help users with the meaning of the '+' and '-' options, the words 'add items' and 'delete items' were added to the switch.

Between the first and second iteration of the design, the graphic representing the product was changed from a picture of the item to a rectangular block containing the branding. This change was made to the design to ensure that the icons used were easily interchangeable to allow the service stations to customise.

Standard snack vending machines tend to hold somewhere between six and forty different products. This meant that the interface had to be able to display more than the eight products allocated for a screen. To cater for this, 'more' buttons were placed on screens that required them. The two triangular buttons,

one pointing to the left and the other to the right, could be used to move between the contents of a vending machine. Text indicating how many screens were available for each vending machine was displayed between the 'more' buttons (ie. 3 of 4).

In the last iteration, a bolder bar was used to separate the vending machine selection from the product selection. While earlier versions had the two sections separated, the differentiation was not clear to all users.

Car Related Purchases

The later version of the car related purchases screens are shown below.



Car wash selection



Oil grade selection



Oil size selection

The main differences between the non-car related purchases screens and the car related purchases screens are detailed in the following paragraphs.

The main selection buttons in this section of dynamic screens are:

- Car wash;
- Oil;
- Valvemaster.

The car wash and Valvemaster purchase screens incorporate the use of up to four long buttons as opposed to the eight shorter buttons. With the car wash this allows the features of each wash type to be detailed.

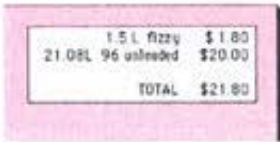
The oil selection screen required an extra level to the selection process. The first level allows the user to select the grade of oil they wish to purchase. Once the grade has been selected the system displays a second menu that allows the users to select the amount required. The second menu contains the size, price, and amount purchased for each item. A 'menu' button is also displayed to allow the user to return to the oil grade selection.

Completing the Transaction



Once the user has made all their purchases, the complete transaction button on the static screen is pressed. If the customer has not inserted a card during the transaction or selected to pay instore, they are asked to do so at this point. If a card were captured by the FST for the duration of the transaction, the card would now be ejected. Otherwise the customer is shown their receipt on screen while a paper receipt is printed. Flashing arrows along with messages, indicate to the user where to remove their card or receipt. When the user has removed the card and receipt from the FST, a thank-you message is displayed. Following this message the system resets itself and resumes displaying advertising.

Receipt



Version 1



Version 2

The customer can request to view the purchase receipt at any stage during their transaction. Once the transaction is being finalised the receipt is automatically displayed on screen.

In the earlier iterations of the interface the receipt contained a list of the items purchased and the total value of the purchase. The later receipts were modified to display the information in a similar format to the printed receipt. The users' preferred this layout as it gave them the confidence that what they were seeing on screen was what they had purchased.

Thank-You Message

Thank you for visiting this
forecourt service terminal

- Please pay instore as
you leave

Thank you for visiting this
forecourt service terminal

Paying instore

Paying at pump

If the customer selects to pay instore, their receipt will not be printed at the pump. The user will be shown their receipt and prompted to pay instore along with the thank-you message.

Users' who have paid for their products at the pump will be displayed a message thanking them for their service.

Following the final message the screen resets to advertising.

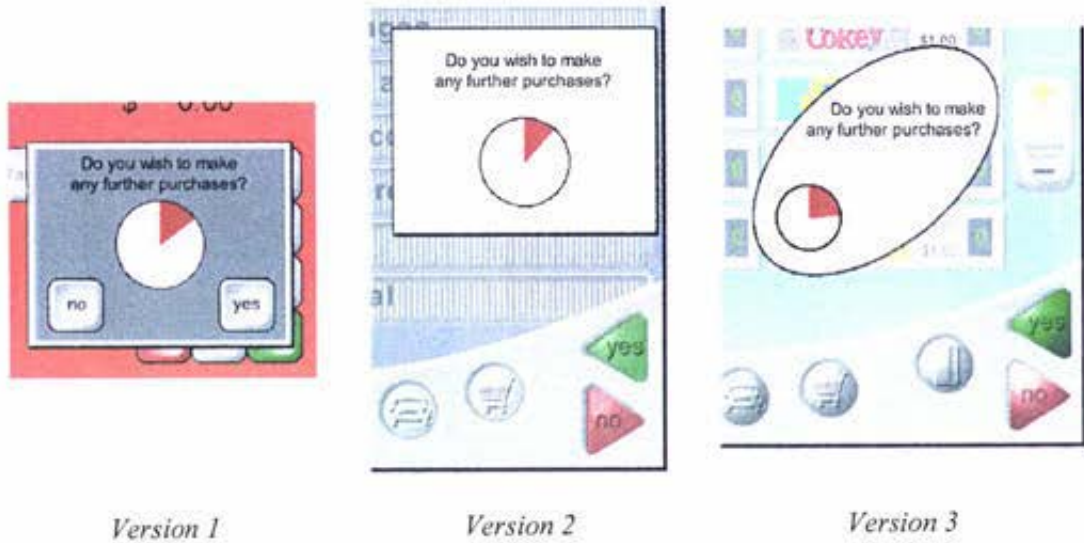
7.2.3 Timeout and Error Messages



Timeout Messages

For security reasons the FST system must be able to terminate a transaction if it feels that the customer has forgotten to do so. If the system did not have this capability and the user left the pump without completing their transaction, subsequent customers could make their purchases on the first user's account.

A timeout message will appear on the screen if the FST detects no action for a certain length of time. The message stays on screen for a period of time, after which, if the user has not requested otherwise, the transaction will be terminated and completed.



The first version of the timeout function displayed a rectangular box over the current dynamic screen. The box contained a message asking the user if they wished to make any further purchases. A clock was used to display the time the user had left to respond. The 'yes' and 'no' buttons in the timeout box were the only active buttons on the screen.

In the second iteration, the dynamic screen was dulled behind the timeout box, and the navigation buttons on the static screen were greyed to indicate that they were not active. To encourage the user to make the link between ending their transaction and pressing the red triangular button on the static screen, the 'no' button was displayed in the same format and location on screen. The 'yes' button was relocated above the 'no' button on the static screen. The style of the 'yes' button was changed to reflect the style of the 'no' button. The triangular shape points back into the interface, and the green colourings represent 'go' or 'start'.

In version 3 the shape of the timeout box was changed to match the curves on the static screen.

Error Messages

Error messages are displayed when something unexpected occurs during a transaction. Once an error message has been displayed on the screen the message remains on the screen until the user acknowledges it.



Version 1

Version 2

Initially error messages were displayed using the standard computer operating system alerts. This was a temporary step performed to enable the content and location of the error messages to be tested.

The final versions display the error messages using the same structure as the timeout box. The error messages appear in the same location on the screen and the two active buttons have the same functions. The green button returns the user to the interface while the red (bye) button exits the user from the interface.

8 Development of the Physical User Interface

The physical user interface refers to the system that houses the components of the FST terminal. These items are listed below:

- LCD screen,
- Touch sensitive panel,
- Internal processor,
- Card reader, and
- Printer.

There are four possible scenarios for the physical user interface:

Redesign the Pump

- The entire pump could be redesigned incorporating an FST unit.
- This would allow for the most flexibility in design, layout, and location.
- A pump redesign would be costly to produce both in time and resources.
- Existing service stations wishing to invest in the new FST technology would be required to purchase the entire integrated pump mechanism.

Replace the Pump Head

- The FST system could replace the head on a petrol pump. Pump heads currently contain the counter displays. It is intended that the FST screen will eventually replace the existing pump counters.
- Approval would need to be attained by PEC to replace the current pump counters.
- This option would allow freedom in the design of the physical user interface as sizing and layout would not be restricted by existing pump heads.
- Retrofitting of the FST system would require the old pump head to be removed and replaced by a new head containing the FST.

Mount the FST in the Pump Head

- The physical user interface could be designed to fit inside a pump head.
- This would allow the FST to be retrofitted into pumps at little extra cost to service stations.
- The design would be restricted by the sizes of the current pump heads.
- Not all of the current range of pump heads would be physically able to contain all of the components required by the FST.

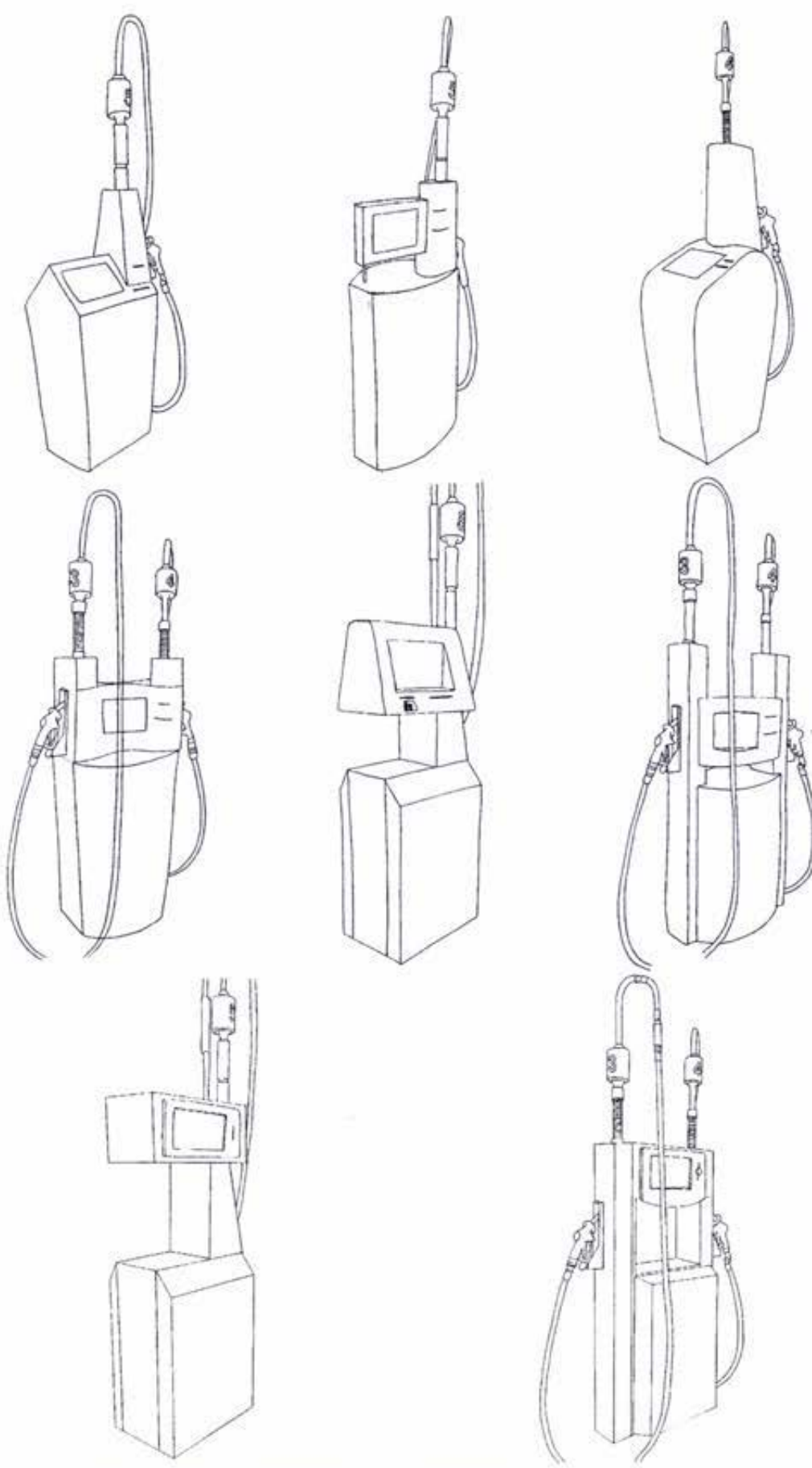


Fig. 8.1: Design Concepts for the Physical User Interface

Mount the FST Independently

- The fourth option would be to mount the FST unit in a freestanding pedestal, or into a wall or column.
- Having a separate unit means that additional space is required on the forecourt to house the FST.
- The FST unit could be retrofitted into any existing service station environment.
- FST units could also be mounted away from the petrol pumps to be used by customers making purchases other than fuel.

A selection of early design concepts for the mounting of an FST unit into a pump are shown in figure 8.1.

PEC has decided to pursue the third option, mounting the FST system into the pump head.

In early focus groups, some participants indicated that they would like to be able to remain in the car to use the FST. In order for the customer to use the FST while remaining in their vehicle, the FST screen, card reader, and printer would need to be able to be moved. This is not a feasible solution within the service station environment. As vehicles are constantly driving up to and away from petrol pumps, the risks involved with having a moving physical interface are too great. Breakages caused by people either driving away with or driving into FST units would be costly to mend or replace. The physical user interface therefore needed to be able to be solidly attached into the pump head.

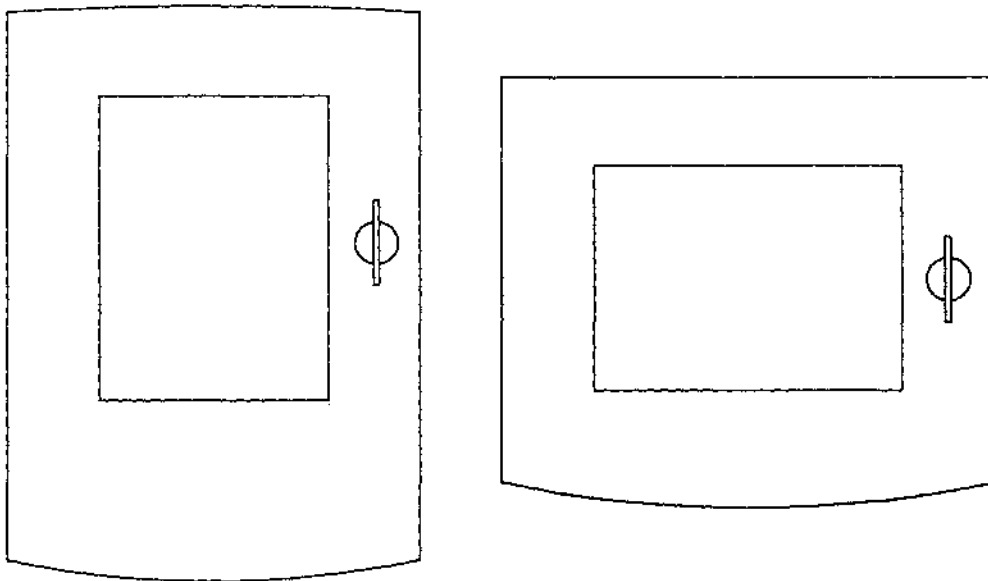


Fig. 8.2a: Front Elevations showing preferred Physical User Interface concepts



Fig. 8.2b: Plan Views showing curve on front surface of the Physical User Interface

A range of shapes was tested for both horizontally and vertically mounted screens. Different combinations of curves and straight lines were investigated along with varying aspect ratios to determine the most visually pleasing solutions. The two designs selected are shown below.

Full size custom-wood models were made of the two preferred physical user interface concepts. The models were constructed to be used in the consumer testing of the FST Interface.

Photographs of the two custom-wood models are shown in figure 8.3.

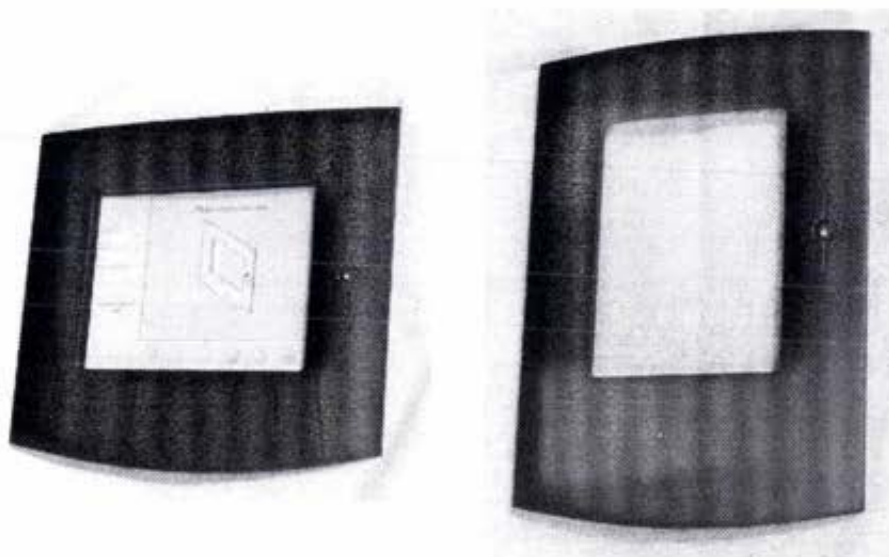


Fig. 8.3: Custom-wood models of Physical User Interface

It was decided to pursue the horizontal mounting of the FST, as the shorter and wider footprint is more compatible with existing pump heads.

Within PEC, designs for the physical user interface are being constructed to encapsulate the components housed within the unit in the most compact form. Diagrams indicating sizing for the current FST physical user interface are shown in figure 8.4.

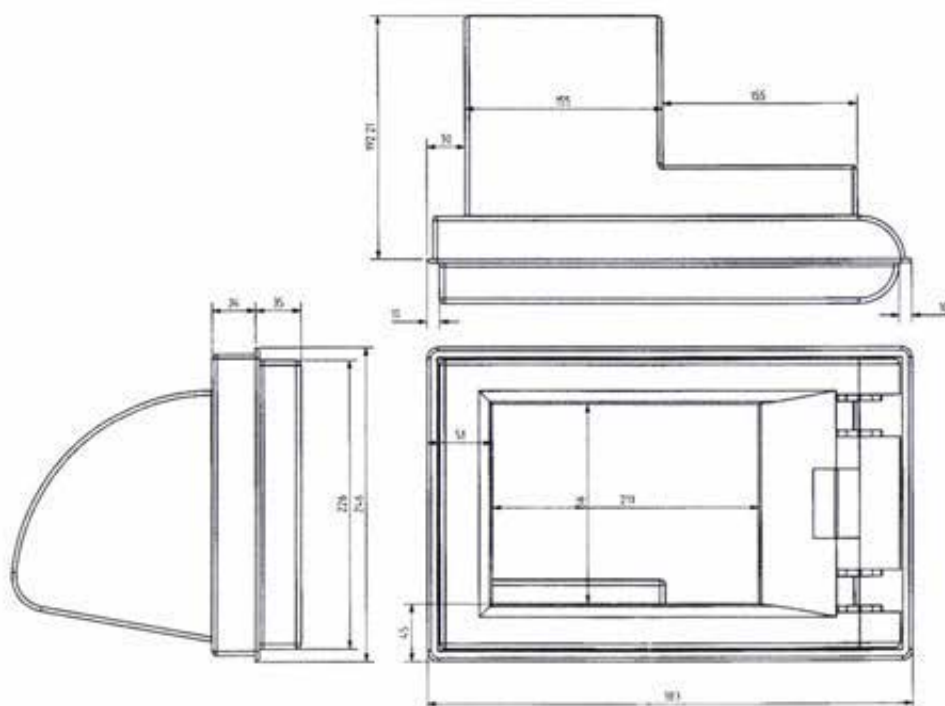


Fig. 8.4a: Plan and elevations of current Physical User Interface

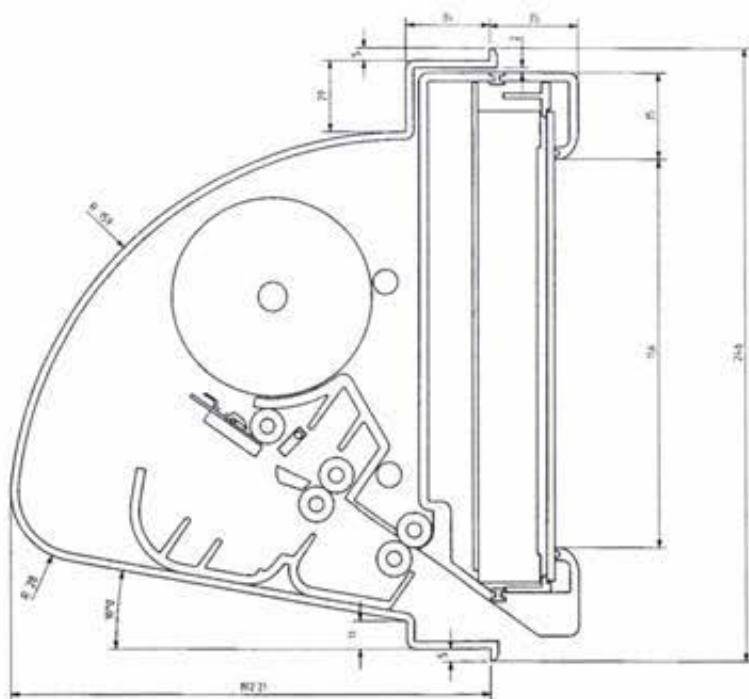


Fig. 8.4b: Section through side elevation indicating location of printer and paper

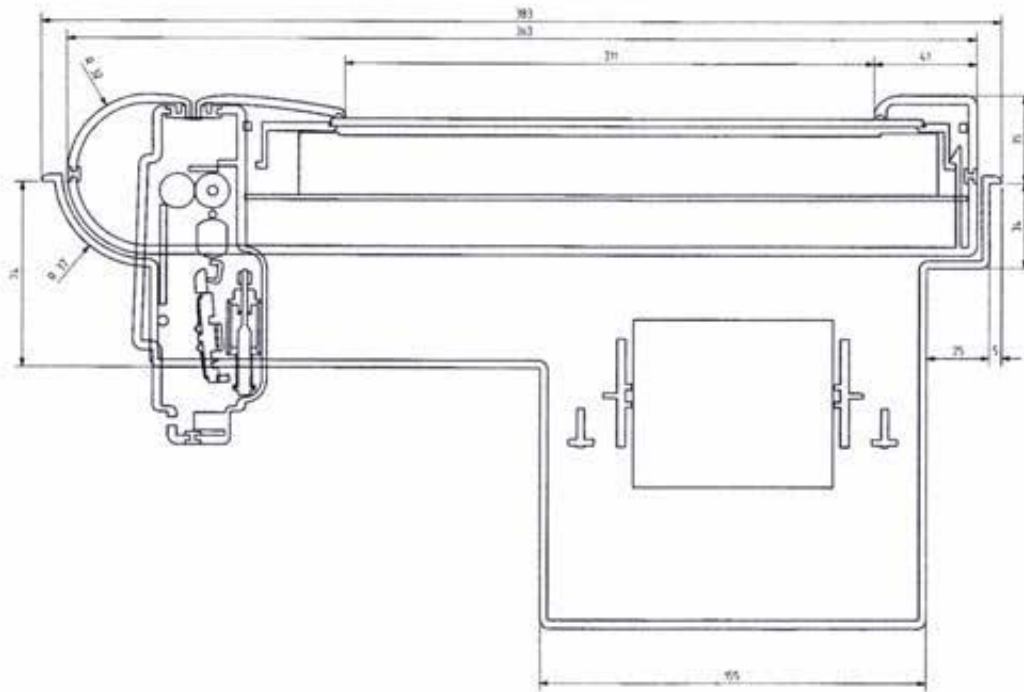


Fig. 8.4c: Plan section showing card reader and printer

A foam model of the physical user interface shown in figures 8.4a-c was constructed to help visualise the shape and size of the unit.

The foam model, as photographed, is shown in figure 8.5.

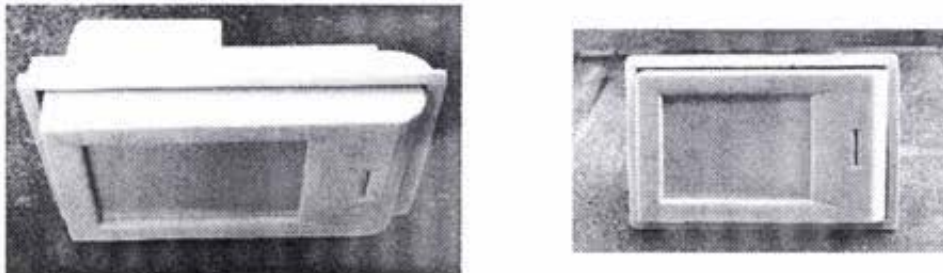


Fig. 8.5: Foam model of Physical User Interface

The model has been used within PEC to help “sell” the concept of the FST to the marketing unit.

The physical user interface is constantly changing with the continuing modification and development of components such as the printer and card reader by PEC staff.

9 Testing and Evaluation

Testing and Evaluation procedures used during the various stages of the product development included:

Observation

- Current forecourt users (see chapter 4);
- Test rig users.

Canvassing Opinion

- Current user survey (see chapter 4);
- Focus Groups (see chapter 4 and 10);
- Technical opinion on initial storyboard (see chapter 6);
- Director storyboard evaluation (see chapter 7);
- Director storyboard survey form (see appendix ii);
- Management decision sought on desirable specifications and preferences.

Formal Consumer Testing

- Interface components;
- Interface prototype mounted in test rig;
- Refined product design.

Further detail is provided for the formal consumer testing conducted on the developing multimedia touch screen interface.

9.1 Interface Component Testing

A short questionnaire was constructed in Macromedia Director 6.0. The questionnaire was designed to be completed by a person using a computer with a touch screen. Responses were saved on the computer desktop.

- A selection of four different shapes of button were presented for pressing to survey preferred size and spacing.
- A range of icons and words that might be used to represent a subject or action, were presented to survey preferred verbal or pictorial association.
- Colour test screen preferences were offered but the number of responses did not allow a clear preference to be identified. This testing section would benefit from extra development.

9.2 Development of Test Rig

According to Hix and Hartson (1993) there are two different forms of testing for a user interface, laboratory testing and field testing.

Laboratory testing involves bringing the participant to the interface within an unnatural working environment for the system.

Field testing involves the testing of the current interface in situ, in the normal working environment in which users are expected to use the interface.

The earlier versions of interface prototype were evaluated using the first method, laboratory testing, where the majority of conditions were artificial. Testers viewed the interface models while sitting at a computer desk, with a mouse in the place of a touch panel, and a keyboard to define external actions such as inserting a card.

It was necessary to test the interface in a more realistic environment. Field testing within a service station can only be carried out once the hardware to drive the FST has been programmed. However the user interface needed to be tested and defined before the hardware programming could begin.

An intermediate step in the testing process was required. It was decided to construct a test rig that would place the user in a setting as close to reality as possible.

A test area was constructed on a trolley to aid with its mobility. Features of the rig included:

- The latest version of the Director prototype interface.
- Touch panel mounted into custom-wood physical user interface model;
- Computer monitor at eye-level (when standing);
- Existing pump head casing;
- Card slot and card;
- Push buttons to simulate pump nozzles.

An existing product made by PEC for an Australian client incorporates a 14-inch television tube into a pump head. A picture of this pump head is shown in figure 9.1.



Fig. 9.1: Existing pump head

The perspex panel in the front facia made this head ideal to be used in the test rig. The facia was bolted to brackets on a trolley and used to hide the computer components driving the interface. The use of the existing pump head gave the test rig a believable front-end, and helped to remove the idea that the FST was a computer based application.

A rear view of the test rig trolley indicating the configuration of computer peripherals behind the existing pump front is shown below:

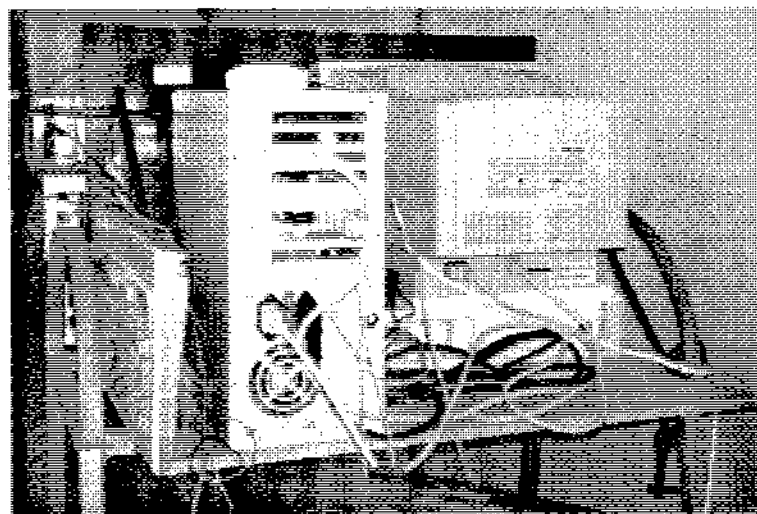


Fig. 9.2: Rear view of test rig showing location of computer

A 14-inch SVGA computer monitor, displaying the 10.7 inch interface screen, was propped behind the perspex section of the pump head. In the final product the screen will be a flat Liquid Crystal Display (LCD) as opposed to the curved computer monitor.

An infrared touch panel was mounted into the custom-wood Physical User Interface (PUI) detailed in chapter 8. The PUI was then attached to the front of the pump head using Velcro.

To replace the previously used keyboard commands simulating external actions such as lifting a pump or inserting a card, a combination of push buttons and a micro-switch were hard-wired to the keys contacts.

Push buttons were allocated to three different grades of fuel (indicative of the range of pump nozzles available on a forecourt). When one of these buttons is pressed, the fuel delivery counter is either started or stopped depending on the filling status of the system before the press.

A micro-switch mounted inside a card slot was used to simulate an EFTPOS or fuelcard transaction. When a dummy card is pressed into the card slot the system registers a card read. Similarly, removing the card from the slot ejects the card in the interface simulation.

Two additional push buttons were added to start and stop the FST demonstration.

The trolley on which the test rig was constructed raised the height of the touch panel and screen to around eye-level. Testers trialing the interface were required to stand while using the system. This mirrors the scenario that would occur when an FST is mounted into an existing pump head on a service station forecourt.

The external action section of the test rig and the trolley used to mount the system are shown in figures 9.3 and 9.4.

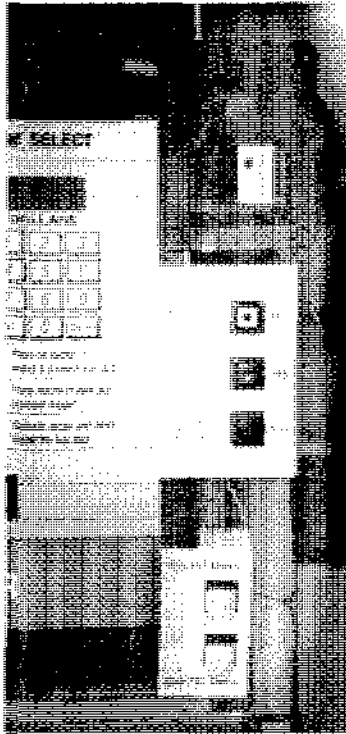


Fig. 9.3: External action buttons

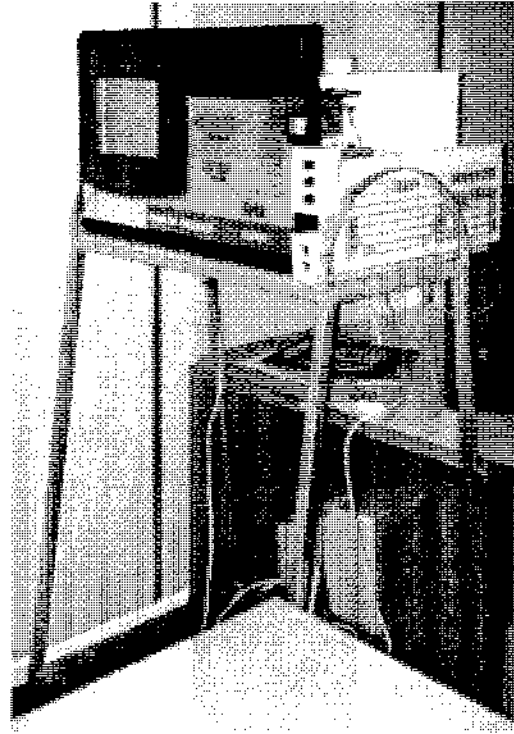


Fig. 9.4: Test rig mounted on trolley

The following picture of the final test rig shows the mounted FST unit used to consumer test the interface.

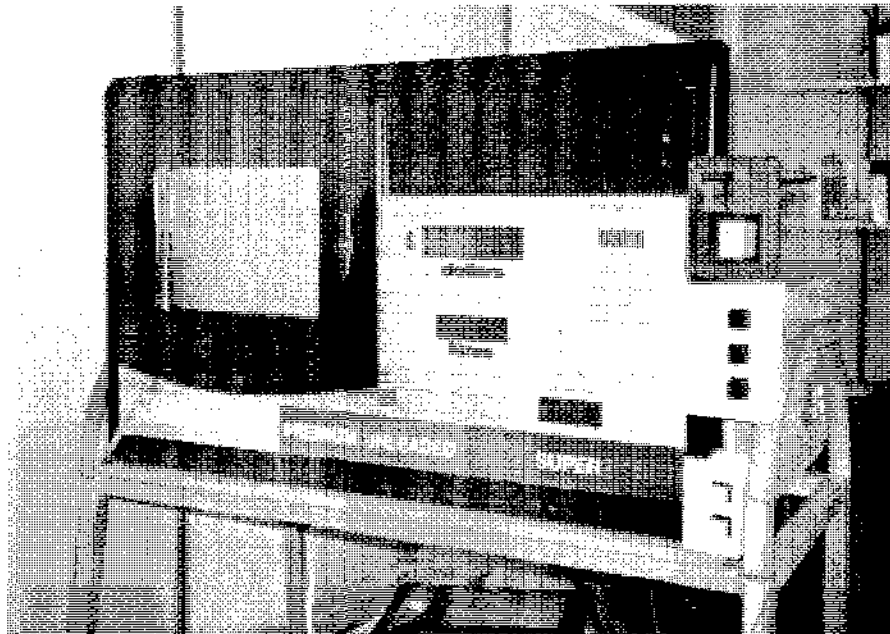


Fig. 9.5: Test rig

9.3 Test Rigged Interface Testing

A questionnaire was developed to enable the interface to be evaluated by a variety of people, with differing backgrounds and expertise, as representatives of the possible end users. The application of the questionnaire provided a means of identifying areas of excellence, plus any problems, difficulties, weaknesses, and areas for improvement.

The questionnaire was divided into four sections:

- Introduction,
- Detail,
- Expectations,
- General.

The first section was specifically concerned with any usability problems that the evaluator encountered while carrying out the tasks.

When answering a question in the first three sections, the evaluator ticked one of five options. The options in the first section ranged between 'no problems' and 'major problems'. In the middle two sections the options ranged between 'always' and 'never'. Of these, 'always' was the most favourable reply, and 'never' was the least favourable. There was a space beside each question for the evaluator to make linked comments.

At the end of the middle two sections, a space was provided for the evaluator to add any other comments, good or bad, of relevance to the issues raised within the section. This was followed by a five-point rating scale, ranging from 'very satisfactory' to 'very unsatisfactory', which enabled the evaluator to give a general assessment of the interface in terms of the criterion and questions within the section.

The final section consisted of general questions on system usability. The questions were 'open', allowing the evaluator to express opinions of various factors including the best and worst aspects of the system, those aspects which caused the most difficulty, and any suggested improvements.

A prerequisite to the questionnaire, was that the evaluator used the FST interface to carry out a series of tasks representative of those which the interface was designed to perform.

A set of four 'shopping lists' was compiled to direct the evaluator into testing as much of the system, and as many functions, as possible. The four lists asked the evaluator to purchase items representative of those they might purchase when faced with the system in a forecourt environment, and to pay for those items using the different methods offered by the system.

According to Johnson and Ravden (1989) some reasons for constructing set tasks to ensure the validity the user interface evaluation are as follows:

- Tasks, which are realistic and representative of the work for which the system has been designed, provide the most effective way of demonstrating the system's functionality.
- This approach enables those evaluating the interface to see it not simply as a series of screens but a part of the application system as a whole.
- By carrying out tasks, evaluators can be exposed to as many aspects of the user interface as possible. This is necessary if they are to comment usefully, and in detail, on specific features, problems, strengths and deficiencies.
- Many significant problems and difficulties are only revealed when carrying out tasks.
- In some cases, there may be important aspects of usability that can only be captured by using the system.

In this project the evaluators were casually observed while completing their set tasks. Observation was used to help identify difficulties, confusions, and common mistakes that the evaluators experienced when interacting with the system.

In addition, the system was set up to independently record information about the evaluators' run through on the FST interface. The time taken, method of payment, and items purchased were recorded for each shopping list. The first and fourth shopping lists were very similar in content allowing the time taken for the evaluator to complete the first and last lists to be compared. The method of payment and items purchased were compared with those on the shopping list, indicating which tasks were able to be carried out successfully by the evaluator.

The need to involve the end users in the design and evaluation of computer based systems is important (Mumford, 1983; Gould and Lewis, 1985). Ideally the same user interface and system should be tested, before implementation, by a cross section those likely to use the system (Johnson and Ravden, 1989).

Due to the commercial sensitivity of the system, the testing of the interface was restricted to PEC employees. This was not limiting as the number and variety of staff members at PEC provided a large base of potential evaluators. In addition to the representative end users, other evaluators such as the FST project team who had not been involved in the design and development of the interface, were used to provide an objective viewpoint from a technical perspective.

Different consumers were used to test the interface components and the interface to avoid adding an unnecessary bias to either set of results.

10 Results and Analysis of Interface Testing

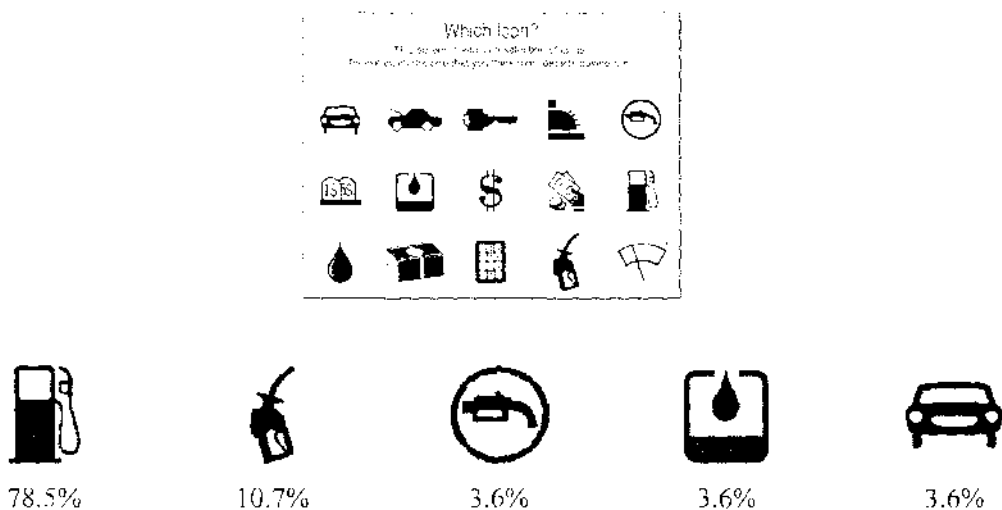
10.1 Interface Components

Section 1

The first six screens asked the user to select the icon or word that most depicted the following events:

- Buying fuel
- Entering card and payment details
- Buying a car related product
- Buying a product
- Completing a transaction

Buying Fuel



The most commonly selected icon depicting a fuel purchase was the petrol pump.

Entering card and payment details





The majority of testers selected either the plain card or set of three credit cards to depict entering card and payment details. This indicates a connection between a card and payment.

Buying a car related product



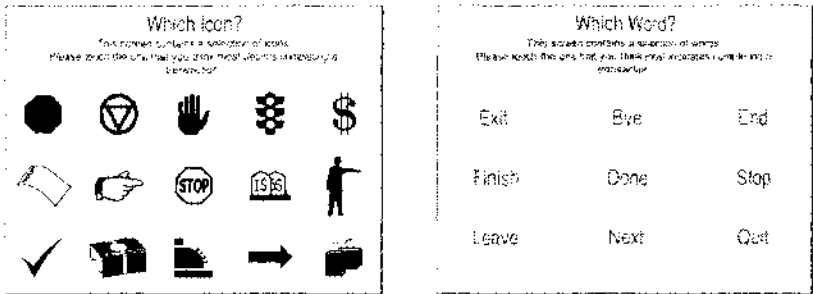
The most common icons selected to represent purchase car related products were the two car icons, followed by the oil can and the tyre.

Buying a product



The majority of responses to this question indicated that the trolley icon most depicted buying a product. None of the remaining seventeen icons received more than one vote.

Completing a Transaction



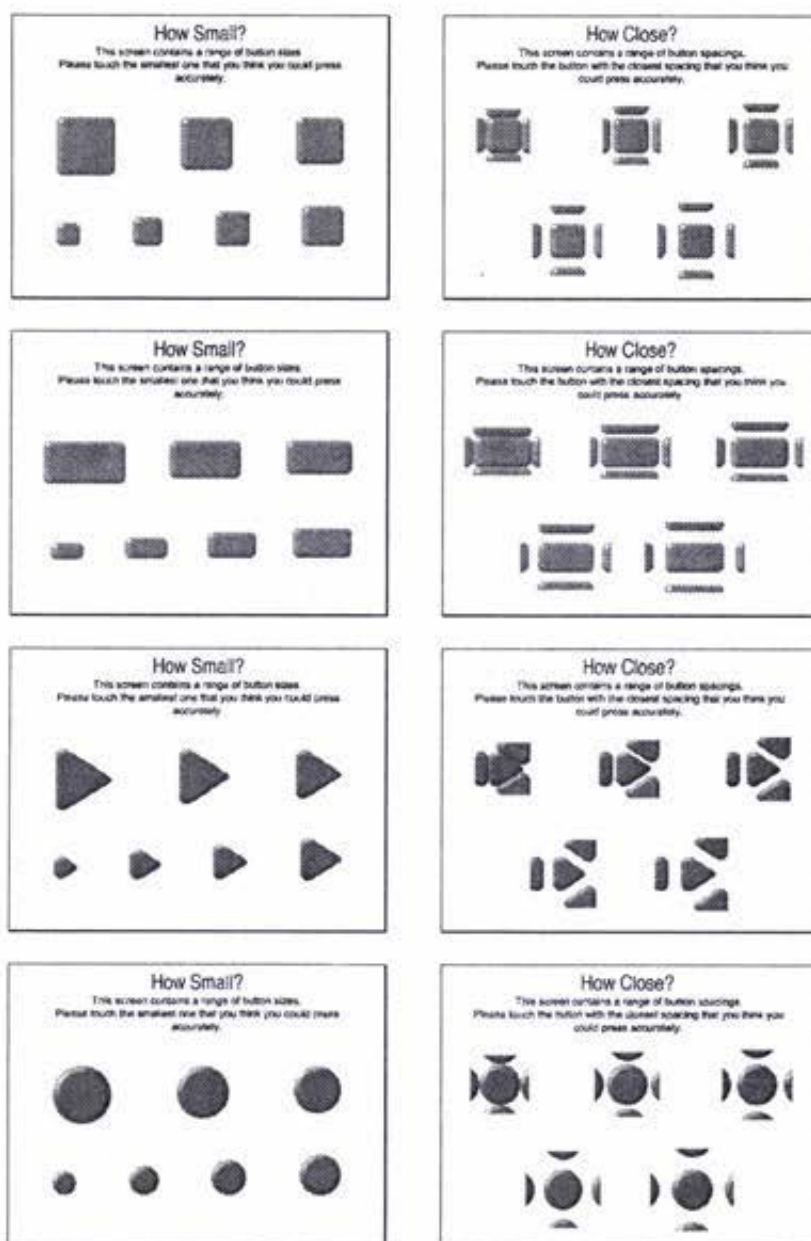
The most commonly selected icon was the tick. However, with less than half of the testers selecting this icon, further research is required. The receipt received the second highest vote.

done	finish	exit	end
57.9%	21.1%	10.5%	10.5%

The majority of users selected the word ‘done’ to depict completing a transaction. Like its icon counterpart, the majority vote is not high enough to indicate universal recognition and understanding.

Section 2

The next eight screens asked the user to select the smallest button they would feel comfortable about touching accurately and then to select the smallest spacing they would have between buttons of this size. The four different button shapes used were square, rectangular, triangular, and round.



Button Sizing

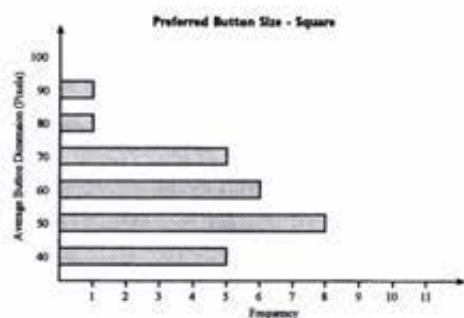


Fig. 10.1a: Square button sizing

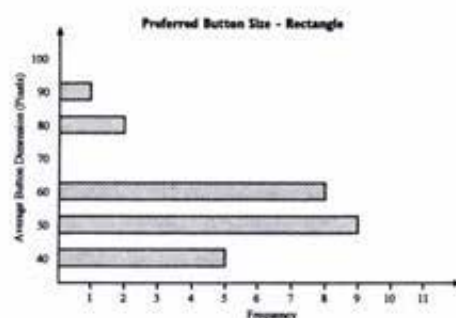


Fig. 10.1b: Rectangular button sizing

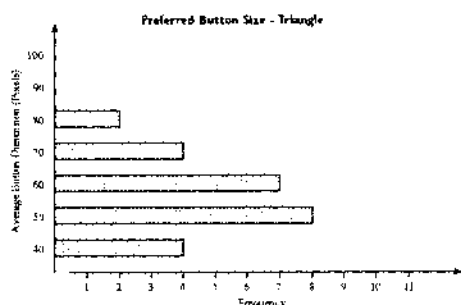


Fig. 10.3c: Triangular button sizing

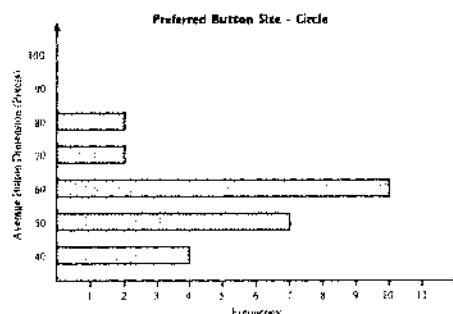


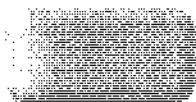
Fig. 10.1d: Round button sizing

Figure 10.1 shows the button sizing preferences for the four different shapes used. The mean button size selected for each shape was used to indicate a suitable button size for use in the interface.

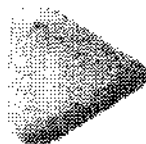
Mean button sizes:



Square 56.4 pixels
(1.86 x 1.86cm)



Rectangular 55.2 pixels
(1.31 x 2.55cm)



Triangular 56.8 pixels
(1.89 x 1.89cm)



Round 56.4 pixels
(1.86 x 1.86 cm)

The shape of the target area appears to be insignificant when determining size.

The mean button sizes selected by consumers answering this questionnaire were smaller than the button sizes used on the FST graphical user interface.

Button Spacing

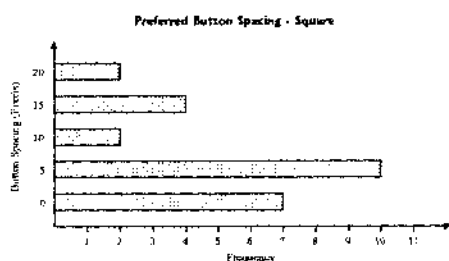


Fig. 10.2a: Square button spacing

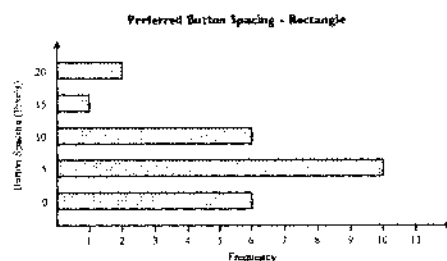


Fig. 10.2b: Rectangular button spacing

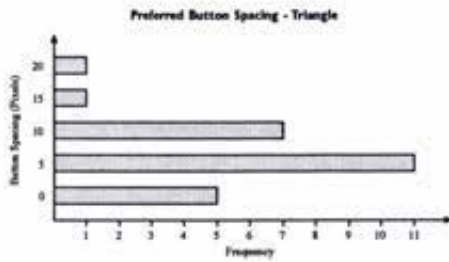


Fig. 10.2c: Triangular button spacing

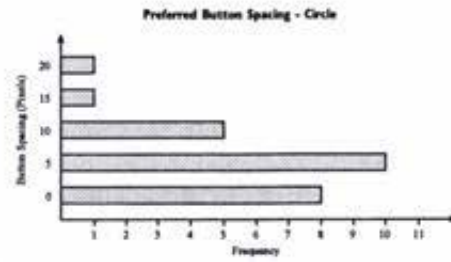


Fig. 10.2d: Round button spacing

Figure 10.2 displays the button spacing data collected from the interface component questionnaire. The most commonly selected button spacing for each of the four shapes was 5 pixel's or about 2mm. As with the button sizing, the preferred button spacing appears to be independent of the button shape.

10.2 Test Rigged Interface

10.2.1 Using the Interface Prototype

The first and last of the evaluators four attempts on the FST prototype were of the most interest. The items that the user was required to purchase were very similar in these two lists. It was hoped that an improvement in the form of a lower error rate and faster performance time would be seen. The degree of difference between the two sets of results would give an indication of the learning time.

Each of the tasks on the list required selection of a product type and quantity. Errors assigned to each task were:

<i>Task Pair</i>	<i>Error Assigned</i>
Correct product and correct quantity	0 error
Correct product and incorrect quantity	0.5 error
Incorrect product and correct quantity	0.5 error
Incorrect product and incorrect error	1 error
Additional purchase	1 error
Missing purchase	1 error

The results for the first and last purchase lists are shown in figure 10.3 and 10.4.

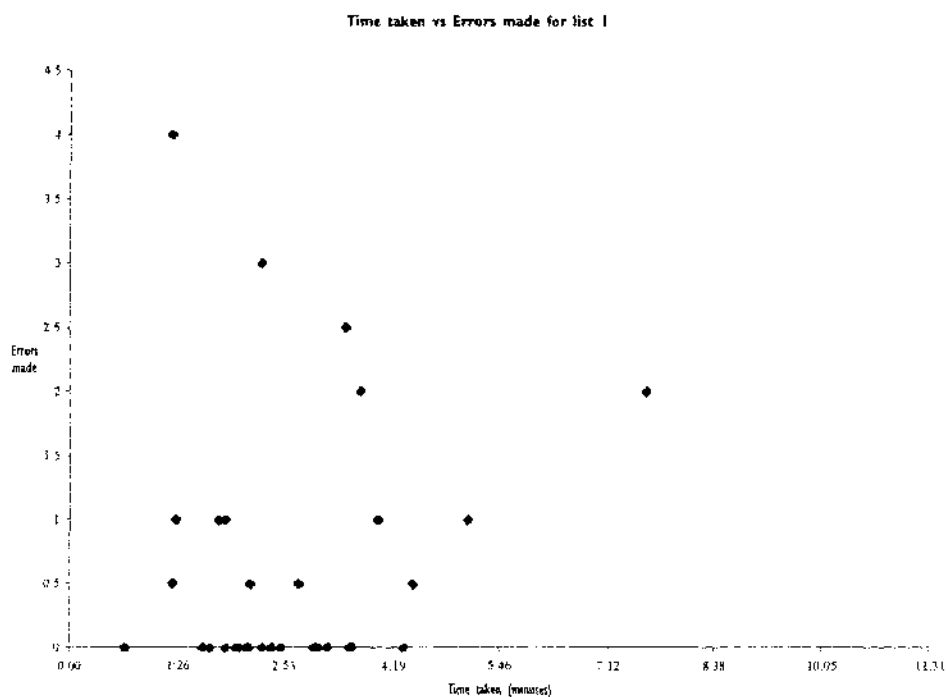


Fig. 10.3: Graph showing time taken vs errors made by evaluators using List 1

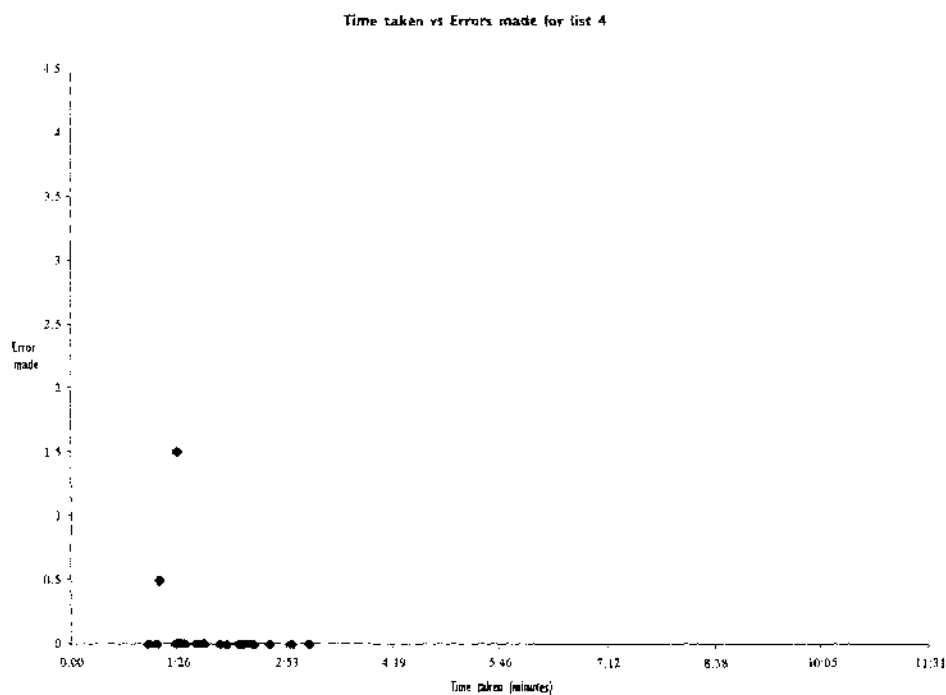


Fig. 10.4: Graph showing time taken vs errors made by evaluators using List 4

Figures 10.3 and 10.4 show the evaluators made a significant improvement in performance between their first and fourth attempt. The average time taken to complete the list went from 2:56 to 1:51 and the average number of errors made per list dropped from 0.64 to 0.06.

Feedback from the evaluators indicated that once they had seen and used a function they were able to reuse it with no further problems. This statement supports the data collected through the trial interface runs.

Some confusion was caused due to the test rig not creating an identical environment for use. There were button simulating the pump nozzles and forecourt vending machines were not available for the user to view potential purchases. However, all of the items on the four lists were able to be successfully completed by the testers.

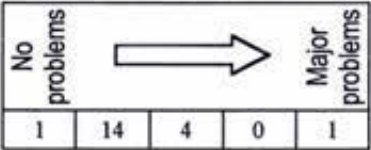
A full version of the data collected during testing is displayed in appendix iv.

10.2.2 The Questionnaire

Section 1: Introduction

Question 1

When using the system did you experience problems working out how to use the system?

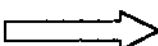


The actual numbers of responses in each division are given at the base of diagram.

Question 1 related to how well the evaluator was able to work out how to use the system. The majority of responses to this question indicated that minor problems were encountered. The problems described by the evaluators mainly related to the first run through, working out how to use each of the functions available in the system for the first time. Once each function had been used a few times the evaluators generally had no further problems.

Question 2

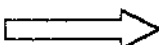
When using the system did you experience problems understanding how to carry out the tasks?

No problems  Major problems				
4	11	3	2	0

Question 2 asked the evaluators how well they were able to carry out their set tasks. One main confusion was not knowing which of the categories (fuel, car related products, other products, and payment method) to find each list item in. Problems were encountered by some of the evaluators who did not know what all of the items on the lists were. Purchasing 'Valvemaster', a fuel additive required by some cars, caused the most confusion. However, in a real situation a customer purchasing a product would almost certainly know what that product was. The other main problem encountered was how to end a transaction. To most of the evaluators' pressing the button marked 'end' was not obvious.

Question 3

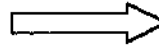
When using the system did you experience problems knowing what to do next?

No problems  Major problems				
1	9	5	2	0

Question 3 related to the user knowing what to do at each stage of the interface. Most of the evaluators' experienced some problems. The first few times through the system caused the most confusion. The instructions, in the bottom left-hand corner of the screen, provided to guide the user through the system, were not seen by all the evaluators. Another feature causing problems was the receipt. A receipt showing all the purchases made by the user was available at all times by pressing the 'instruction box'. Pressing the instruction box when the receipt was visible caused the receipt to become hidden and vice versa. However, the message explaining this action was not always displayed in the instruction box, this lead to confusion about how to get rid of a receipt which was possibly covering up essential parts of the screen.

Question 4


When using the system did you experience problems understanding how the information on screen relates to what you are doing?

No problems  Major problems				
14	5	1	0	0

Question 4 asked the evaluator if they understood how the information presented on the screen was relevant to what they were doing at the time. Overall few problems were encountered.

Question 5

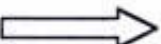
When using the system did you experience problems finding the information you wanted?

No problems					Major problems
6	8	4	2	0	

Question 5 asked the evaluators if they had any difficulties finding information they wanted. This question showed that the majority of users experienced some problems. The main problem area was the product purchasing. The system has the potential to be able to sell a large range of products. This however brings in problems relating to the user finding the item they wish to purchase amongst the numerous entries. To cover all the items available in a standard sized dispensing machine (up to 40 different items) the prototype required several sub menus. The evaluators were not always sure which of the sub menus would contain the item they wished to purchase.

Question 6


When using the system did you experience problems with information that was difficult to read clearly?

No problems					Major problems
10	7	1	1	0	

Question 6 related to how easily information on the screen could be read. Two main areas were highlighted. The first was the instruction box. The text size (14 pt) used to display instructions was small compared to other text displayed, and some of the evaluators failed to notice this text. The second area was the product names displayed in the other purchases section. Branding logos were used, as opposed to straight text, to help aid in the recognition of products. The use of the logos made some of the product names a little difficult to read.

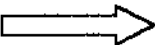
Question 7

When using the system did you experience problems with too many colours on the screen?

No problems					Major problems
19	0	0	0	0	

Question 8

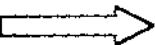
When using the system did you experience problems with colours that were difficult to look at for any length of time?

No problems					Major problems
19	0	0	0	0	

Question 7 and 8 asked the evaluator about the colours used in the interface, whether there were too many colours or whether any of the colours were hard to look at. None of the evaluators' had any problems with these aspects of the system.

Question 9

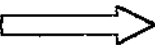
When using the system did you experience problems being able to do things the way you wanted?

No problems					Major problems
7	7	2	2	1	

Question 9 asked the user if they were able to perform the set tasks the way in which they wanted. The majority of comments that were made about this question related to the physical test rig as opposed to the interface. The test rig used an ordinary computer monitor behind the touch sensitive panel, instead of the flat LCD screen that the system will eventually use. The curved monitor caused parallax errors making accurate presses of buttons on the screen more difficult. The other main problem, also arising from the test rig, was the use of physical buttons to mimic the operation of the pump nozzles. Confusion occurred when instructions on screen asked the user to lift a pump, meaning they had to press a button on the test rig. This type of confusion would not be a problem in a real situation.

Question 10

When using the system did you experience problems losing track of where you were in the system or of what you were doing or had done?

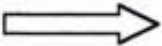
No problems					Major problems
9	5	4	1	1	

Question 10 asks if the evaluator experienced any problems associated with losing track of what they were doing. About half of the evaluators' had no problems. Minor problems were experienced by most of the other testers. The biggest problem area highlighted was the receipt and purchase total. Some of the users did not realise that their purchase total was visible on the screen at all times and a receipt showing a breakdown of their purchases was available at all

times. Others discovered how to view their receipt but not how to hide it again once it was visible.

Question 11


When using the system did you experience problems with unexpected actions by the system?

No problems  Major problems				
11	5	0	2	0

Question 11 relates to any unexpected action made by the system. One problem was perceived by an evaluator who believed that once payment details had been completed no further purchases could be made. The system has been designed to be flexible and allow users to purchase items and enter payment details in any order. Hiding and showing the receipt was once again highlighted as a problem. Once a receipt was made visible it remained visible until the user asked the system to hide it, some of the evaluators' were expecting the receipt to automatically be hidden on other screens. Another function that caused confusion was the add/delete switch used to toggle between adding and deleting products. When the switch was on the '+' setting, pressing a product button added one of that item to the purchase total, and similarly, when the switch was on the '-' setting, pressing a product button deleted one of that item from the purchase total.

Question 12

When using the system did you experience problems with the touch screen being difficult or awkward to use?

No problems  Major problems				
5	9	4	1	0

Question 12 asked the evaluators how they found the touch screen to use. Most experienced some problems. The majority of problems arose from the use of a curved computer monitor rather than a flat LCD panel behind the touch panel. The monitor could not be pressed flat against the touch panel meaning that parallax errors occurred unless the user was looking perpendicularly at the interface. The parallax errors were accentuated by users leaning against a nearby wall as opposed to standing directly in front of the system. The different heights of the evaluators also caused problems. As the screen was around 2cm back from the touch panel at the corners, some of the information and buttons on the screen were obscured to taller users by the touch panel mounting.

Question 13

When using the system did you experience problems having to spend too much time inputting information?

No problems			Major problems		
9	9	1	0	0	

Question 13 asked the evaluator whether they had had any problems with the amount of time it took them to enter information. Most of the evaluators either experienced no or very few problems. Problems that were experienced related to the users not being able to quickly locate products in the menu screens.

Question 14

When using the system did you experience problems with having to be very careful to avoid errors?

No problems			Major problems		
6	7	3	3	1	

Question 14 related to the problems that the evaluator had had avoiding errors. Most of the evaluators indicated that they had experienced some degree of difficulty in avoiding errors. However, the majority of these problems arose from the use of the touch panel and computer monitor as described in question 12.

Question 15

When using the system did you experience problems working out how to correct errors?

No problems			Major problems		
7	7	3	3	0	

Question 15 asked evaluators whether they had had problems correcting errors. The ‘add/delete’ switch once again caused problems, leaving users not sure how to remove unwanted purchases from their totals. Evaluators also raised the point that a backspace key had been omitted from the keyboard used for alphanumeric data entry. This meant that a mistake made during the data entry required the user to re-enter all of the characters.

Question 16


When using the system did you experience problems with having to carry out the same type of activity in different ways?

No problems			Major problems		
12	6	0	0	0	

Question 16 related to consistency of performing similar tasks. All of the evaluators perceived either no or very few problems in this area.

Question 17


When using the system did you experience problems feeling confident about the system being secure?

No problems					Major problems	
16	3	0	0	0		

Question 17 asked the evaluator whether they felt confident about the security of the system. No significant problems relating to this aspect of the system were raised.

Question 18

When using the system did you experience problems with system errors or malfunctions?

No problems					Major problems	
14	2	2	1	0		

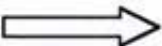
The final question in the introductory section asked the evaluators if they had had any problems with system malfunctions or errors. Most of the evaluators experienced no problems. The problems that were raised were not actually due to system errors or malfunctions, and have been discussed in previous questions.

Section 2: Detail

Question 1

When entering information on the screen, is it clear:

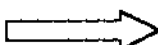
*Where information should be entered?
In what format it should be entered?*

Always					Never	
6	13	1	0	0		
13	6	0	0	0		

Both the speed and efficiency of an interaction will be increased if a user can see where they should enter information on a screen, and if the format in which the information should be entered is obvious to them. No significant problems were highlighted in this specific area by the evaluators.

Question 2

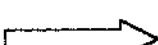
Does information appear to be organised logically on the screen?

Always					Never
6	13	1	0	0	

If the location, layout and order in which the information is displayed appears to be logical to users, then they are likely to find the required information more quickly. Similarly, users may find it easier to understand what the screen is displaying, if information is organised in a way that makes sense to them. Difficulty in finding some of the non-fuel items within the purchase screens was experienced by a few of the evaluators.

Question 3

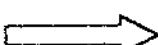
Are different types of information clearly separated from each other on the screen?

Always					Never
14	6	0	0	0	

It is important for the user to be able to identify different types of information on the screen quickly and without difficulty. All of the evaluators indicated that they the different types of information had been satisfactorily separated on screen.

Question 4

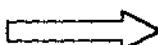
Does the use of colours help to make the displays clear?

Always					Never
17	3	0	0	0	

The effective use of colour can enhance visual clarity, especially for those unfamiliar with the screens. The evaluator responses indicated that the use of colour was beneficial to the clarity of screens.

Question 5


Are the different colours used consistently throughout the system?

Always					Never
13	6	0	0	0	

Consistency is important as it helps to reinforce user expectations by maintaining predicability across the interface. Users indicated that the use of colours was consistent.

Question 6


Is the clarity of information on the screens satisfactory?

Always					Never
5	8	4	2	0	

This question highlighted a few areas of concern. Some of the evaluators did not see vital information such as the instruction box. The navigational buttons using icons to indicate meaning were not always obvious. Other problems arose in the product purchasing section. Items were displayed using their logos or branding. Not all of the evaluators knew the branding for the product they were looking to purchase. In a real environment, the product, in a vending machine, would be visible to the user.

Question 7

Are icons, symbols, graphical representations and other pictorial information used consistently throughout the system?

Always					Never
14	6	0	0	0	


The consistent use of pictorial representations is important so that users can learn to use them quickly and accurately. No problems were highlighted in this area by the evaluators.

Question 8

Is the same type of information (eg instructions, messages, pictures) displayed consistently:

In the same location on screen?

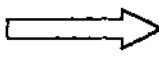
In the same layout?

Always					Never
14	5	0	0	0	
14	4	0	0	0	

The consistent display of similar types of information helps users to learn where to look to find information on the screen. The evaluators indicated that there was no problem with the consistency of the information location. However, some indicated that noticing the information for the first time was not always obvious.

Question 9

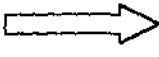
Is the way in which the system responds to a particular action consistent at all times?

Always						Never
15	4	0	0	0		

Having a system that responds in a similar way helps to build predicability. Users indicated that responses provided by the system were almost always consistent.

Question 10

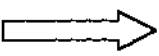
Are messages displayed by the system relevant?

Always						Never
8	9	2	0	0		

It is important that information in the form of instructions and messages is concise and to the point. The main area highlighted for attention was the receipt. A message explaining how the receipt could be displayed and hidden was only shown when the user was in the purchasing screens. This caused confusion on how to use this feature when in other areas of the interface.

Question 11

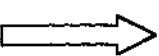
Is it clear what actions you can take at any stage?

Always						Never
4	4	8	2	2		

The response to this question indicates a need for improvement in this area of the interface. Problems were highlighted with the complete transaction section as users were not sure what the 'bye' button was for. Some of the evaluators were unsure when they were able to insert a card. In the existing FST there is only one place where this action can be performed. In the FST mark 3 prototype, card and details can be entered at many stages.

Question 12

Does the system clearly and promptly inform you when it detects an error?

Always						Never
6	3	1	2	1		

The only comments made in response to this question were that the particular evaluator did not receive any error message. As error messages could definitely be activated in the system, the lack of error message perhaps indicates the intuitive nature of the product for those people.

Question 13

Do error messages explain clearly:

What errors are and why they occurred?

How to correct the errors?

<div> <div>Always</div> <div>→</div> <div>Never</div> </div>				
8	3	1	0	0
6	4	2	0	0

As with question 12, comments indicated that the majority of users did not experience an error message during the evaluation process.

Question 14

Is there an easy way to 'undo' an action and step back to the previous stage or screen?

<div> <div>Always</div> <div>→</div> <div>Never</div> </div>				
2	2	7	4	1

Most of the evaluators expressed having trouble at some stage during the trial in this area. One of the main issues raised related to a 'backspace' key omitted from the alphanumeric keyboard.

Overall how would you rate the system in terms of detail?

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory
11	6	1	0	0

All of the responses made to this question were favourable to the interface in the area of detail.

Section 3: Expectations

Question 1

Are colours assigned according to conventional associations where these are important?

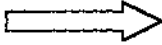
<div> <div>Always</div> <div>→</div> <div>Never</div> </div>				
10	8	1	0	0

The evaluators did not highlight any major problem with this aspect of the design.

Question 2

Where icons, symbols, graphical representations and other pictorial information are displayed:

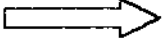
*Are they easy to recognise and understand?
Do they follow conventions where these exist?*

Always  Never				
10	4	3	2	1
11	7	0	0	0

Some problems were experienced by users with the recognition of product branding used to indicate the item of purchase. An icon highlighted as confusing was the car wash logo and symbols. An evaluator also experienced some degree of difficulty with finding all the list items, as they didn't associate the icons displayed at the top of the purchasing screens as buttons.

Question 3

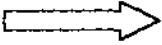
Is information entered into the system displayed in the way you expected?

Always  Never				
8	8	2	0	0

Overall, evaluators were satisfied with the way information was displayed and entered.

Question 4

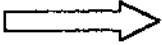
Are established conventions followed for the format in which particular types of information are displayed?

Always  Never				
12	6	2	0	0

The majority of responses indicated that conventions were followed. The data entry causing the most problems was the “+/-” switch used to add or delete items from the purchase total. This switch was not intuitive for its function.

Question 5


Does the sequence of activities required to complete the task follow what you would expect?

Always  Never				
5	9	3	2	0

The main area of concern highlighted in the responses to this question was the expectation of a confirmation of purchases before the completion of a transaction.

Question 6


Is the touch screen appropriate for the tasks to be carried out?

Always					Never
16	4	0	0	0	

Responses to the question indicate that a touch screen is a suitable input device for the FST interface.

Question 7


Is the way in which information is presented appropriate for the tasks?

Always					Never
6	11	1	1	0	

Evaluators indicated that the information provided was mostly appropriate to the tasks. No specific comments identifying areas for improvement were made.

Question 8


Does each screen contain all the information that is required to carry out a task?

Always					Never
10	4	5	1	0	

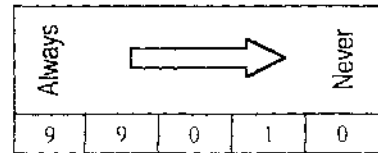
No significant problems were highlighted. However, comments were made by some of the users indicating that for the first time user some of the instructions were not sufficiently “idiot proof”.

Question 9

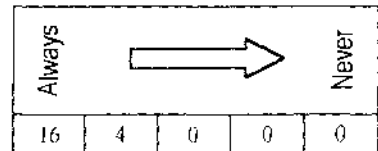
Are you provided with all the options necessary at any particular stage in a task?

Always					Never
8	8	2	2	0	

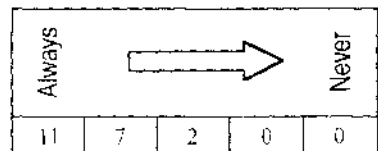
Overall, most users experienced few difficulties in this area. Some of the evaluators indicated the need for a way out such as a ‘back’ button, and the need for better prompting with the receipt feature.

Question 10*Does the system work in the way you think it should work?*

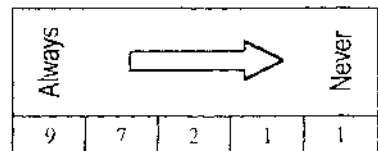
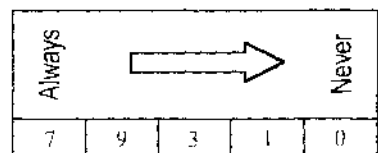
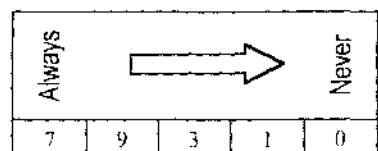
The responses to this question indicate that the system worked in the way the evaluators expected. No comments were made to the contrary.

Question 11*Can you move to the different parts of the system as required?*

The navigation of the interface ceased to be a problem for the majority of users after they found where all the sections were for the first time.

Question 12*Is it clear what part of the system you are in?*

Overall the users location within the system was known. The area causing the most confusion was within the sub menus of the purchase screens.

Question 13*Is it clear what the different parts of the system do?***Question 14***Is the system well organised from the user's point of view?***Question 15***In general, is it clear what the system is doing?*

Mixed responses were made to questions 13, 14, and 15. The general trend indicated that most evaluators found the system clear and organised. The testers offered no specific areas of note for improvement.

Overall how would you rate the system in terms of expectation?

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory
9	6	3	0	0

The evaluators who came into the testing with no expectations of what the system would be like, were either satisfied or moderately satisfied with what they encountered in the prototype interface. This was very encouraging for the developer.

Section 4 – General

Written comments relating to the interface were made by the evaluators on their perceptions of the:

- Best aspects of the system;
- Worst aspects of the system;
- Areas of confusion or difficulty;
- Irritating aspects of the system;
- Commonly experienced difficulties;
- Desirable changes.

Best aspects of the system for the user:

- Simple interface;
- Easy to use logical steps for performing tasks;
- Screen is uncluttered;
- Once mastered is easy and flexible to use;
- Clear graphical interface;
- Recognisable icons;
- Bold colours help to identify different things on screen;
- Novel organisation of screen;
- Looks elegant, simple, and inviting;
- Touch screen more natural than off screen buttons;
- No queuing at an instore counter;
- Comprehensive services.

Worst aspects of the system for the user

- It was not obvious how one should complete the transaction;
- No confirmation was given of your transaction either at time of purchase selection or at time of payment;
- Needed better prompting;
- The process of adding and deleting additional purchases using the "+/-" switch was not intuitive;
- Instructions were not obvious enough;
- User having to stand in wind and rain to use the system.

Parts of the system that were confusing or difficult to understand

- The concept of the possibilities for making other purchases while fuel was being dispensed was not immediately obvious;
- Knowing which button to press to end a transaction;
- Navigating through system for the first time.

Irritating aspects of the system

- No help key;
- Lack of confirmation of actions;
- Not knowing how to hide the receipt once it is displayed on the screen;
- Small buttons on alphanumeric keyboard.
- *Commonly experienced difficulties*
- User not sure if they have performed the correct actions;
- Initial learning period was difficult;
- The system did not take the user anywhere – the user needed to direct the system.

Evaluator suggested changes

- Clearer prompting;
- Advertising during fuel delivery;
- Beep when a button is correctly pressed;
- A help wizard;
- Have "+" and "-" on each purchase button, rather than "+/-" switch;
- A few screens giving a system preview;
- Confirmation of purchase;
- Clearer method of payment;
- Larger keypads;
- Have the terminal as a money machine as well.

As a final question the evaluators were asked to indicate whether they would like to see the prototyped system on a service station forecourt. The unanimous

answer was yes, and one evaluator wanted to see thousands of them out there as quickly as possible.

I Product Evaluation

11.1 Modifications

Following the formal testing of the interface prototype, a focus group was held to discuss areas for improvement as identified in the questionnaires. The aspects of the interface discussed by the focus group included:

- Helping the first time user with learning what to do and where to find things;
- Emphasising the instructions in the instruction box;
- Method for displaying and hiding receipt;
- Navigating the sub menus in product purchasing screens;
- Making the addition and deletion of products intuitive;
- Making the completion of the transaction clear.

Changes and additions were subsequently made to the interface prototype based on the brainstorming session points detailed as follows:

The Instruction Box

Some of the evaluators made comments that the instructions in the instruction box were too detailed while others indicated that the opposite was true. As a compromise, the length of messages displayed was maintained but a range of new messages was added to give extra guidance in the areas where user difficulty had been identified.

To address the issue of the instruction box not being seen by the user, the focus group suggested flashing the messages. However, while a message is flashing it is very difficult to read. A perceived problem arising from flashing the message when it is first displayed is that a user who already knows the location of instructions will be delayed while the message flashes. This could cause the learned user to become annoyed with the system. It was important that any solution found to solve a problem did not introduce another problem of its own.

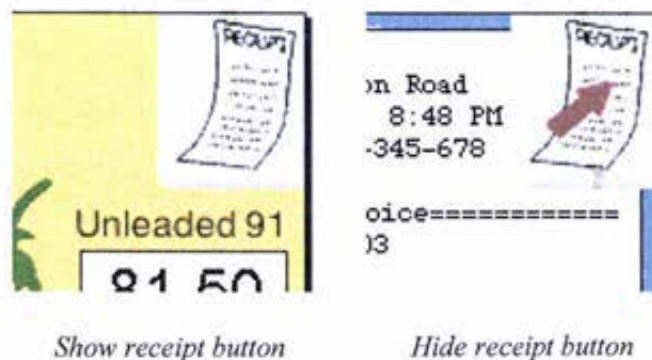
The instruction box has been modified to display additional appropriate messages in the existing location. If the system detects no interaction after a set short period of time, the message now flashes to draw the users attention to the instructions given.

The Receipt

In the prototyped interface a receipt showing purchases made by the user was available to the user at all times. The method of activating the receipt or of hiding the receipt was to press inside the instruction box (ie. the receipt would remain visible once activated until the user specifically chose to have it hidden). Consumer testing showed this to be confusing. In addition, instructions detailing the receipt function were only visible when the user was within either the “car” or “other product” screens. If the user left those screens the instructions about the receipt were replaced by instructions specific for the newly selected screen.

When the receipt is visible, its size means that a large section of screen becomes hidden. If the user cannot hide the receipt, in all probability they will not be able to complete their purchasing at the pump. It was therefore necessary to find a better solution for displaying the receipt.

A button was placed in the upper right-hand corner of the dynamic screen. The button remains visible and active throughout an entire transaction.



The receipt button that was selected is shown above. When the button is pressed the receipt is displayed and the button icon is changed. To hide the receipt, the user can either press the hide receipt button or press the receipt display. If the user moves to another screen section while the receipt function is activated, the receipt will automatically be hidden so full detail of the new screen is visible. The user can reactivate the receipt when required.

The focus group participants indicated that having the purchase total displayed on the screen would be another useful feature, and that having the total might

negate the need for the user to view their receipt often. This was another case of the users not noticing a feature of the interface. The purchase totals had been displayed on the static screen of the interface consistently from the early prototypes.

A feature has been added to the total purchases box so that when the purchase total is altered in any way, the background colour in the box changes, drawing the users eye towards the display.

Navigating the Sub-Menus

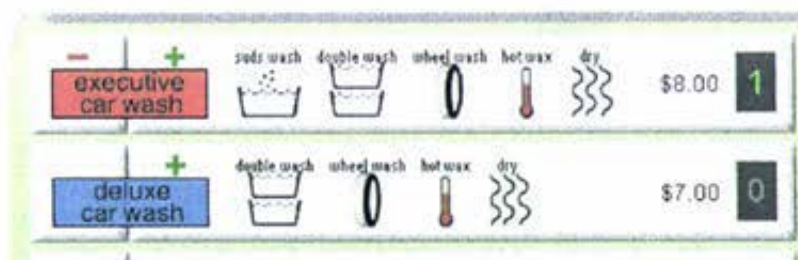
An additional benefit from introducing the receipt button is that the instruction box is freed to display more detailed instructions about purchases in the car and other product sections.

The instruction box can now guide the user with additional messages that indicate which buttons to press to view the product lists of the sub menu screens.

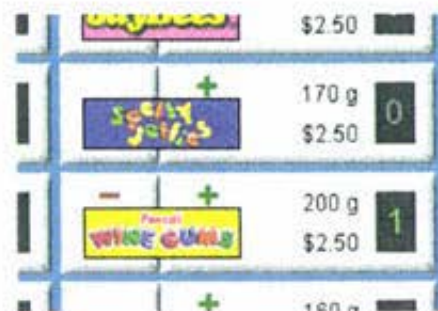
Adding and Deleting Product Purchases

The product add and delete switch confused the consumer testers.

The preferred solution suggested in the focus group was to have two buttons for each product, one with a “+” and one with a “-”.



Long product buttons



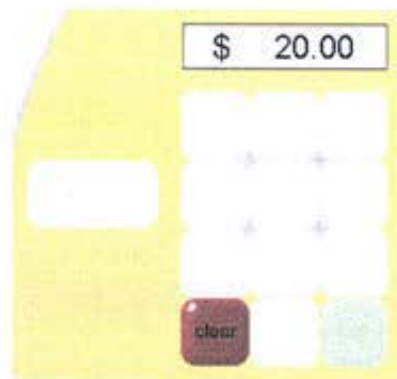
Short Product buttons

The existing product buttons have been divided into two separate buttons. A small square button on the left and a larger rectangular button on the right. The smaller button contains a “-” sign. When none of the product had been purchased the minus sign is greyed out and the button is inactive. The larger button containing most of the product information and a “+” sign is used to add items to the purchase list and the tally of selected items is shown.

This solution is proving to be more intuitive and actually cuts down on the total number of button presses required.

The Fuel Purchase Screens

Some additional functionality was suggested within the fuel preset screens. The first was in response to expressed confusion over whether a fuel preset had been accepted by the system. The interface has been modified so that once the user has successfully selected a fuel preset, the keypad buttons become greyed out. The button with the function to clear the order remains visible to allow the purchaser to change their mind before they dispense their fuel.



Greyed fuel preset buttons

The second suggested alteration was made in response to the need to inform users of the purchasing capabilities of the new FST. An advertising message box is now displayed if fuel is being dispensed while the user is within the fuel purchasing screens. The advertising space will allow the fuel companies to show product specials and availability at the pump.



Advertising during a fuel delivery

Card Screens

An extra function has been included in the card detail section of the screens. An “eject card” button was added to allow the user to cancel their card transaction and remove their card at any stage during the entry of personal details.



Eject and card buttons

Error and Timeout Messages

To aid users in finding the appropriate “yes” or “no” buttons when an error or timeout message is displayed, the message box has been moved closer to the active reply buttons.



Error message

Completing the Transaction

The functionality of the complete transaction button was not clear to all of the users. The wording on the button has been changed from “bye” to “done” (the word identified in the component questionnaire as being most associated with ending a transaction).



Done button

Many of the evaluators expressed the need to have their purchases confirmed before they accepted a transaction. The focus group proposed the addition of another step in the complete transaction screen section.

The interface has been modified to include an extra set of screens. When a user presses the “done” button they are taken to a screen like the one shown below.



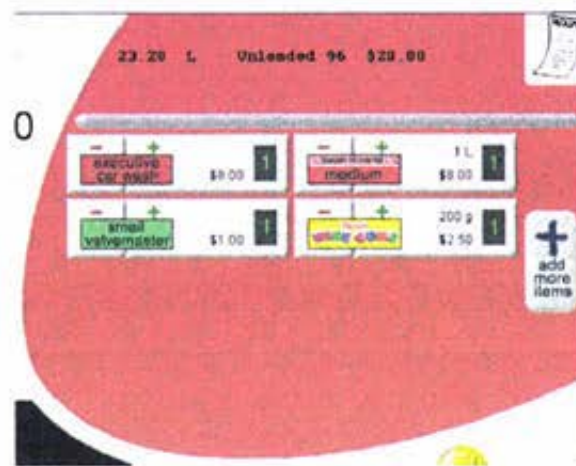
Confirm purchases

The receipt detailing purchases made is shown along with two buttons, “accept” or “change”. Pressing “accept” ends the transaction as before. If the user wishes to modify their purchases they are able to press the “change” button.

When the “change” button is pressed the user is taken to another screen that contains all of their purchases. The purchases that can be altered are displayed as product buttons and others that may not be altered are displayed as text.

An “add more items” button is also available for the user who wants to purchase a different item. Pressing the “add more items” button takes the user back into the main interface screens.

When the user is satisfied they press the “done” button to return to the confirm screen.



Change purchases

11.2 Interface Navigation and Flow

A paper navigational aid has been created for the interface to assist with hardware programming.

Thirteen charts have been constructed (see charts 11.1 – 11.13).

The navigational chart (chart 11.1) shows the possible combinations and orders of events that can be implemented during a transaction. The chart contains interface navigational buttons and independent user actions. Each button and action then has one of the other charts associated with it.

Each button on the navigational chart corresponds to a Dynamic Screen Section (DSS) of the interface. The DSS charts show the basic order of actions that are undergone by the computer relative to the choices made by the user.

Each Independent User Action (IUA) shows the basic order of actions that are undergone by the computer when influenced by an external input.

11.3 Further Work

The Forecourt Service Terminal is an ongoing project for PEC. Further development is to be completed in the following areas:

- Graphical user interface development
- Individual component development
- Physical user interface development
- Internal testing
- Standards approval
- Field testing

11.3.1 Graphical User Interface

The graphical user interface prototype has been through one complete cycle of formal testing and is currently undergoing its second iteration of testing and refinement. The process of testing and refinement will continue until the product reaches the level that allows commencement of the hardware programming.

Testing of some of the interface components (ie. the preferred foreground and background colours for displaying easy to read text) is ongoing.

Aspects of the system still to be investigated include:

- Audio feedback,
- Help function.

Audio Feedback

Currently the system “beeps” with every correct press of an active button. This indicates to the user when they have successfully made contact with an active area of the screen. Other forms of auditory response and assistance are still to be assessed.

Help Function

One of the last features to be included into the prototype interface will be the help function. Once the interface prototype has completed several iterations of testing and refinement, the areas requiring additional help will be able to be identified. The development of help assistance for the interface needs to be concise so users are able to quickly and successfully access the required information.

Development of Interface for Other Markets

The current FST units are sold in many countries. In order for the redesigned FST mark 3 with the graphical user interface to be suitable for sale within these areas, the interface and unit must be able to be modified to meet with local standards, languages, conventions, and practices.

11.3.2 Component Development

Other components and technologies comprising the FST unit are being developed in parallel with the work on the interface.

PEC staff are currently developing the following components:

- Card reader,
- Printer,
- Touch screen,
- Internal processor
- Site controller
- Physical user interface.

11.3.3 Standards Approval

The FST system will need to comply with appropriate standards. The standards include those of:

Fire-rating,

- AS2420 for fire retarding rating of housing material.

Electrical safety,

- AS3000 for electrical safety,
- AS2381 for wiring below vapour barrier.

General safety,

- UL1950 (US) and IEC950 (Europe) – Safety of Information Technology Equipment including Electrical Business Equipment.

Touch screen interfaces,

EFTPOS banking,

- Able to read cards meeting ISO/IEC7816.3 and ISO1177.

Service station practices,

- AS2229 – Electrical Equipment for Explosive Atmospheres – Electrical Systems for Dispensing Equipment – Flammable Liquid Dispensing Equipment,

Telecommunications.

Environment,

- IP56 for waterproofing,
- Able to operate in temperatures between -20°C and 70°C,
- Contaminant resistant to all grades of petrol, car and truck oil, and lead replacement additives.

11.3.4 Field Testing

After the prototyping, testing, and preliminary approval of the individual components has been completed successfully, prototype FST units will be constructed for field testing within a service station.

It is envisaged that the FST incorporating the touch screen graphical user interface will be ready for field testing within the second quarter of the 1999 business year.



Chart 11.1: Interface Navigation Chart

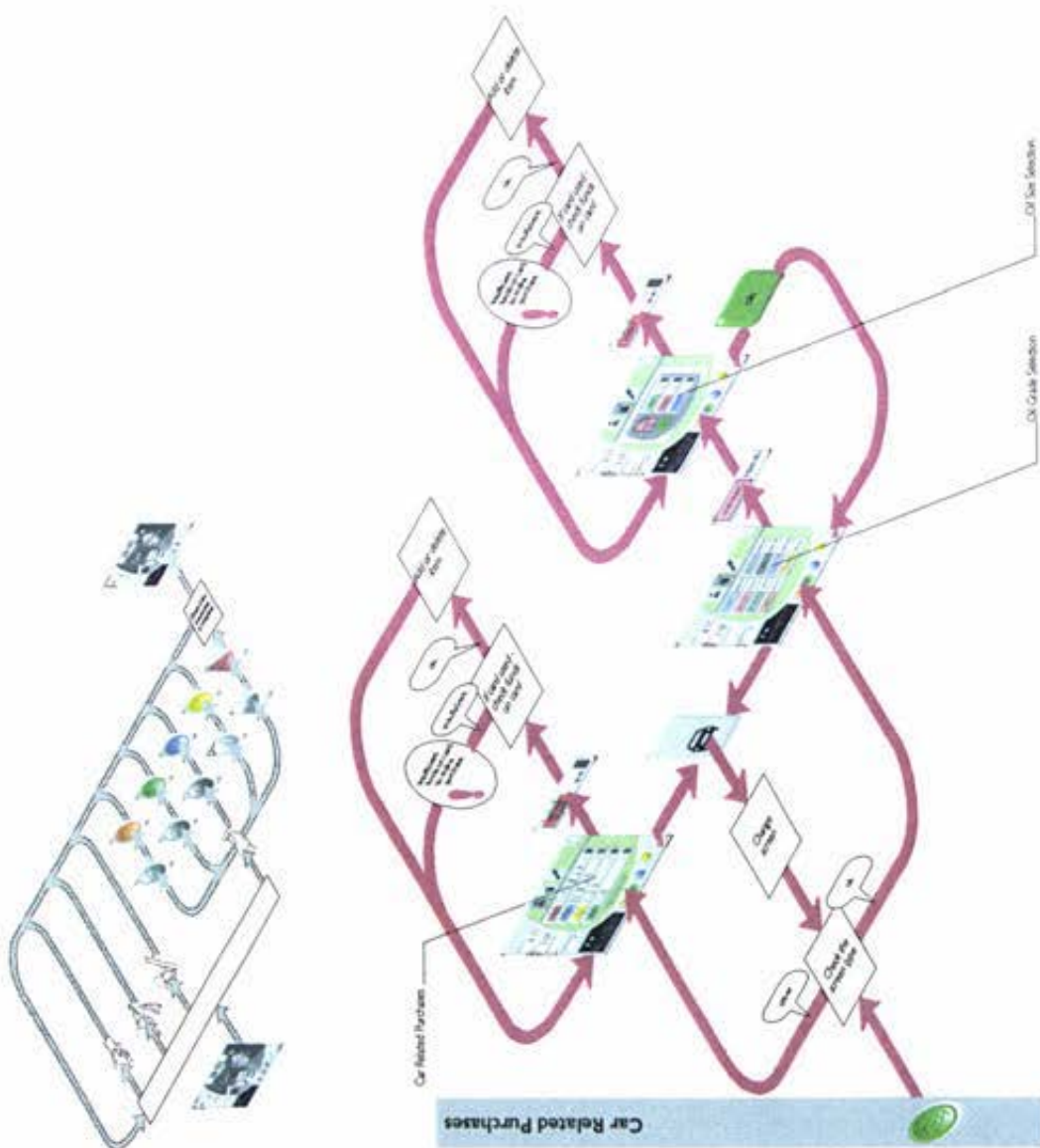


Chart 11.3: Dynamic Screen Section - Car Purchases

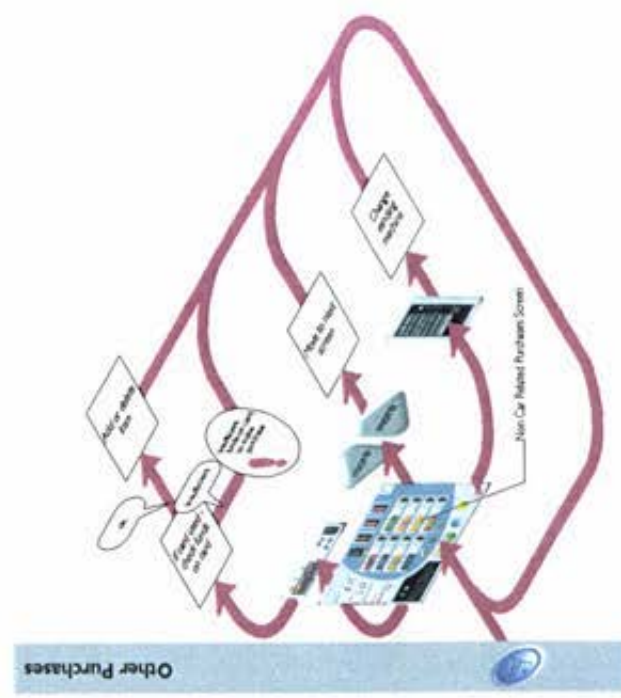


Chart 11.4: Dynamic Screen Section - Other Purchases

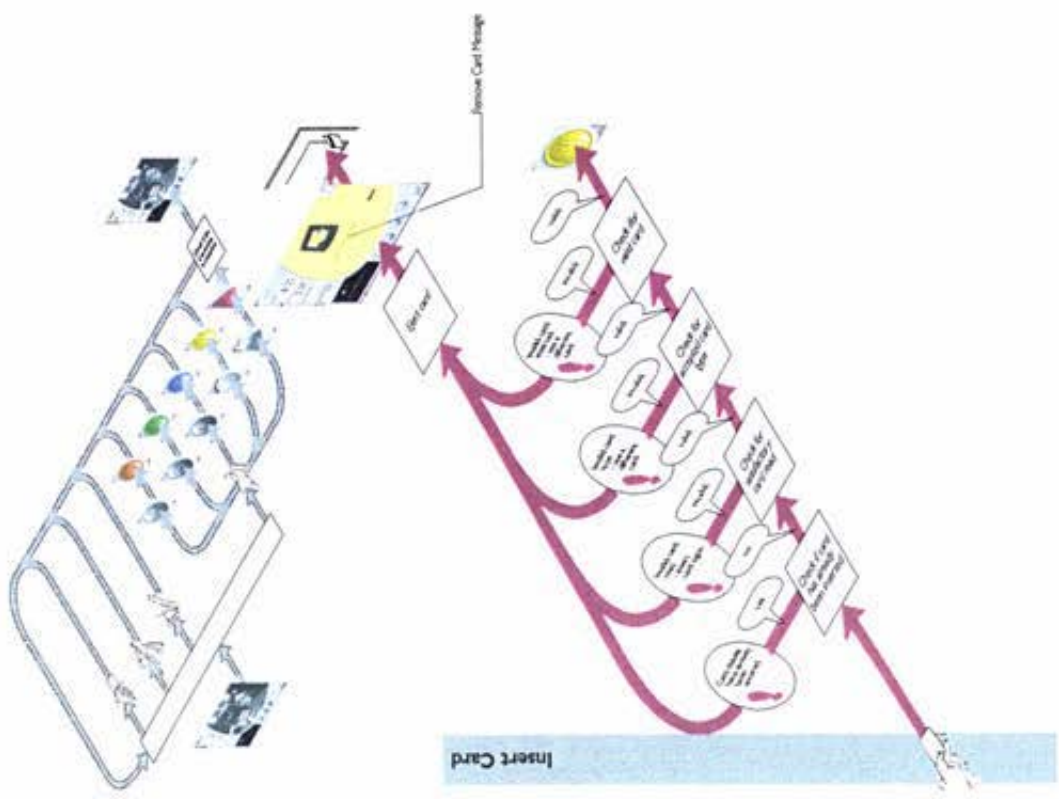


Chart 11.5: Independent User Action - Insert Card

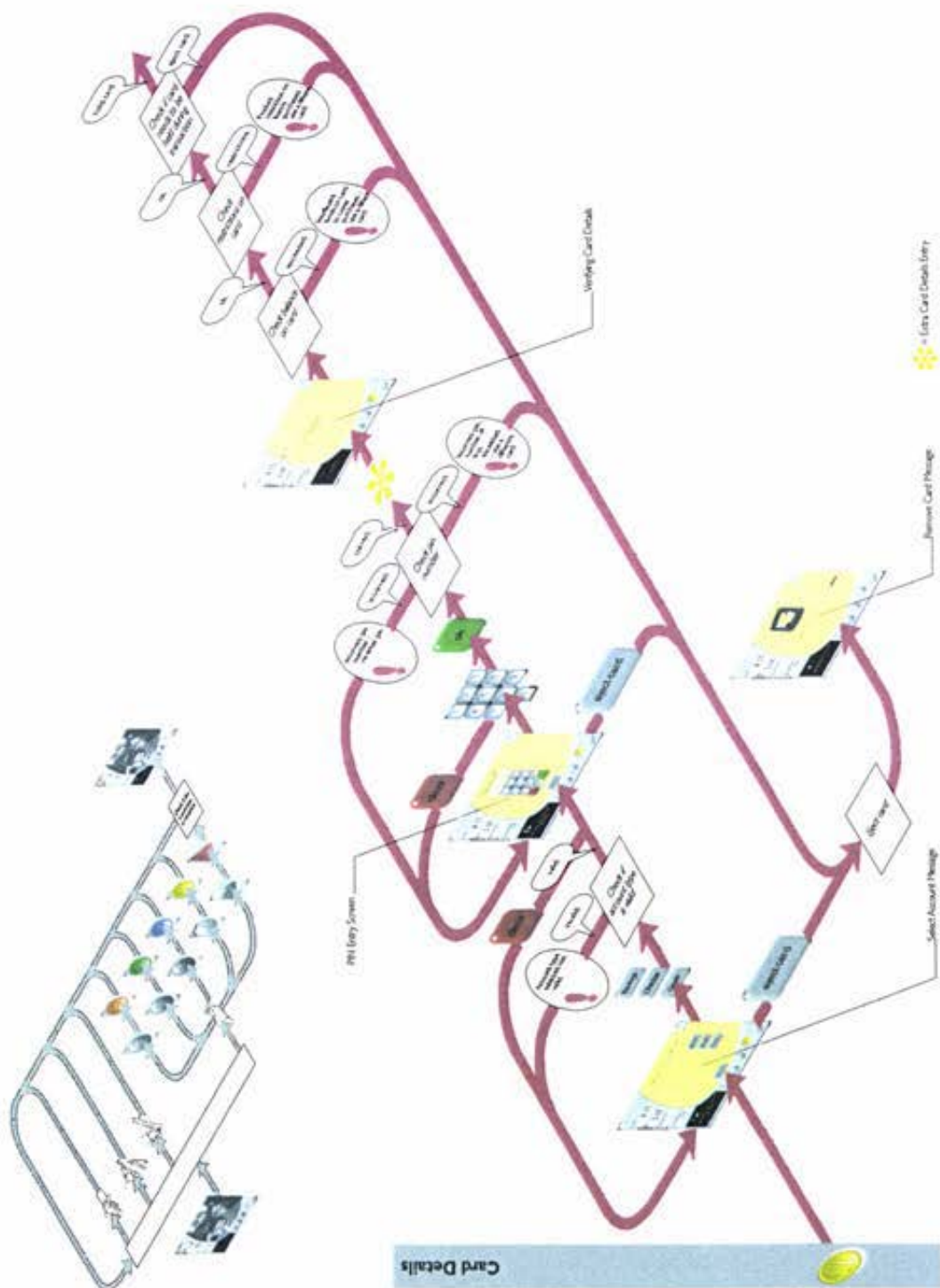
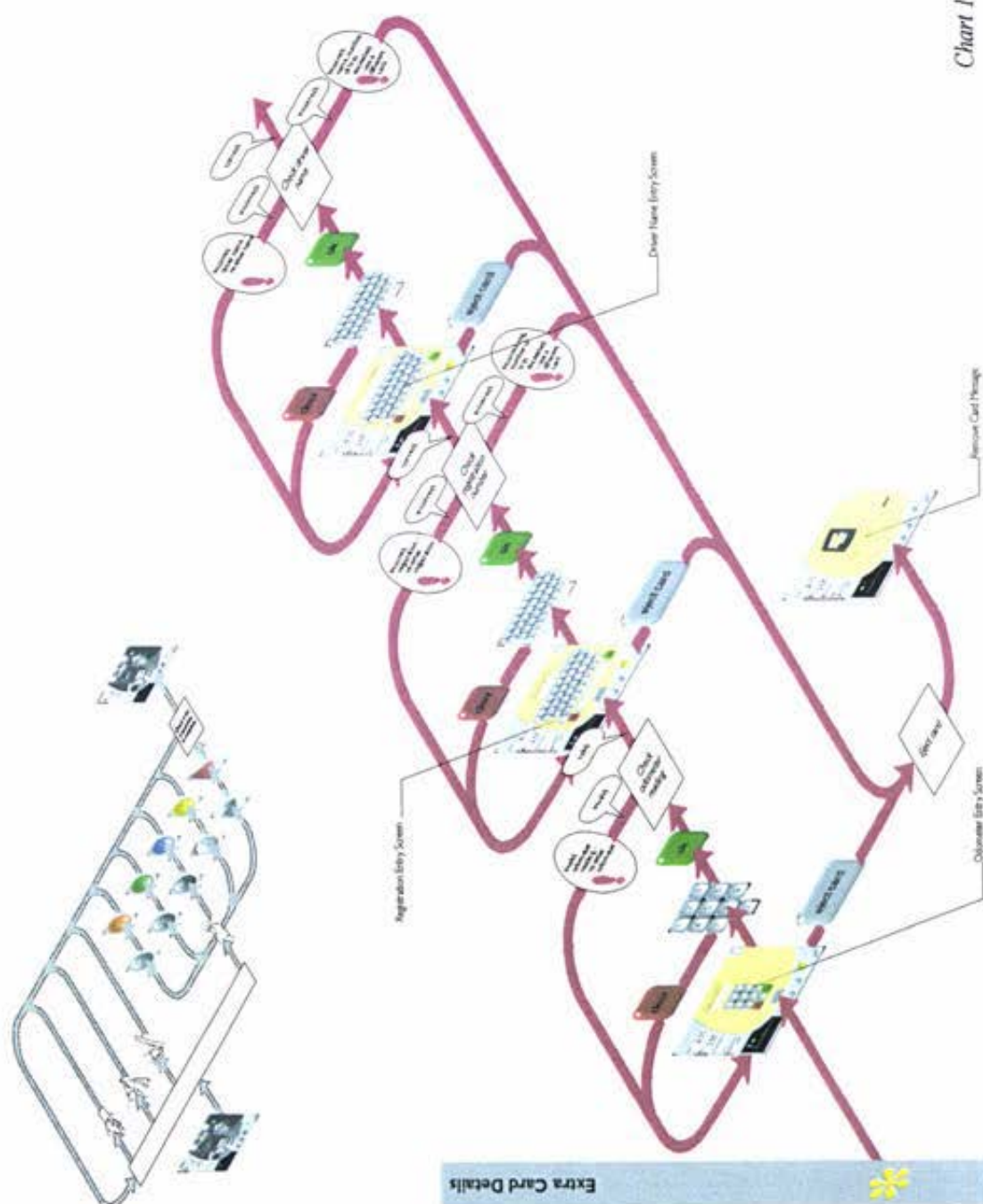


Chart 11.6: Dynamic Screen Section - Card Details



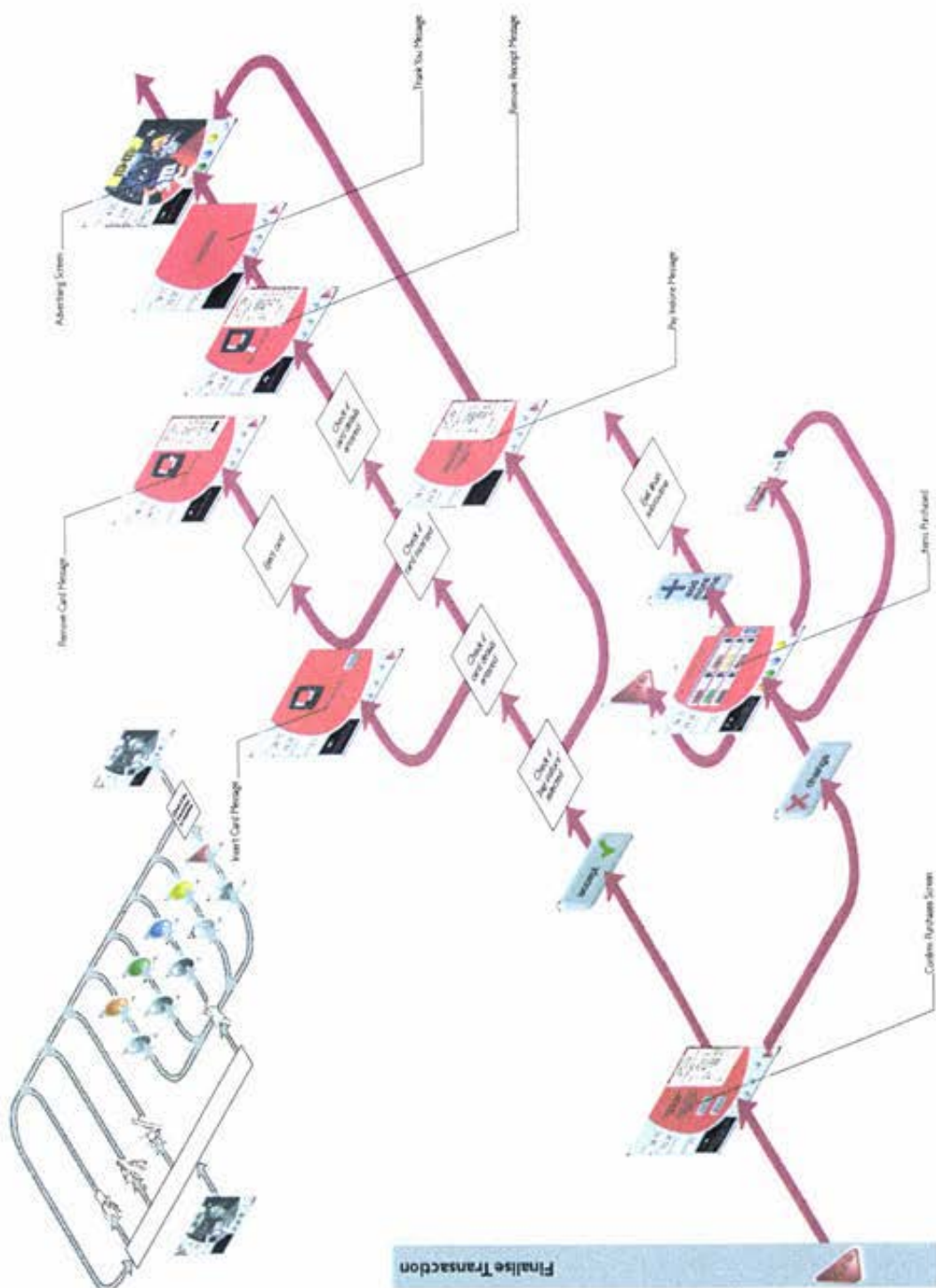


Chart 11.8: Dynamic Screen Section - Finalise Transaction

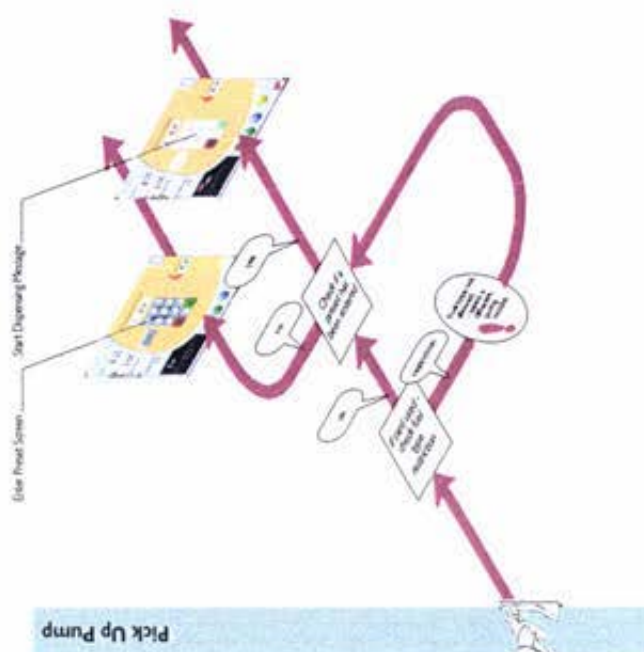


Chart 11.10: Independent User Action - Pick up Pump

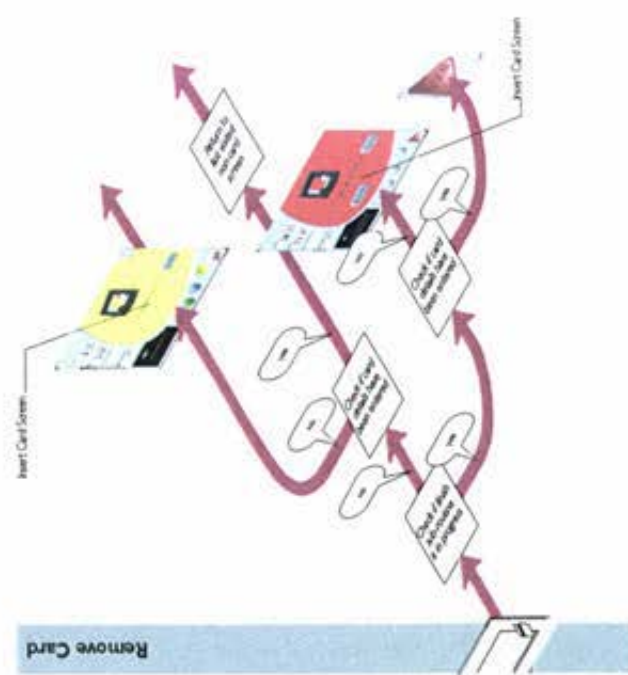
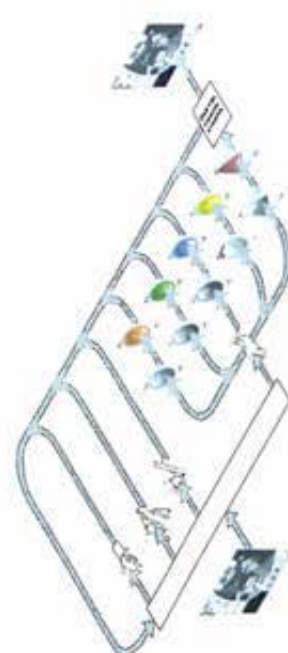


Chart 11.9: Independent User Action - Remove Card

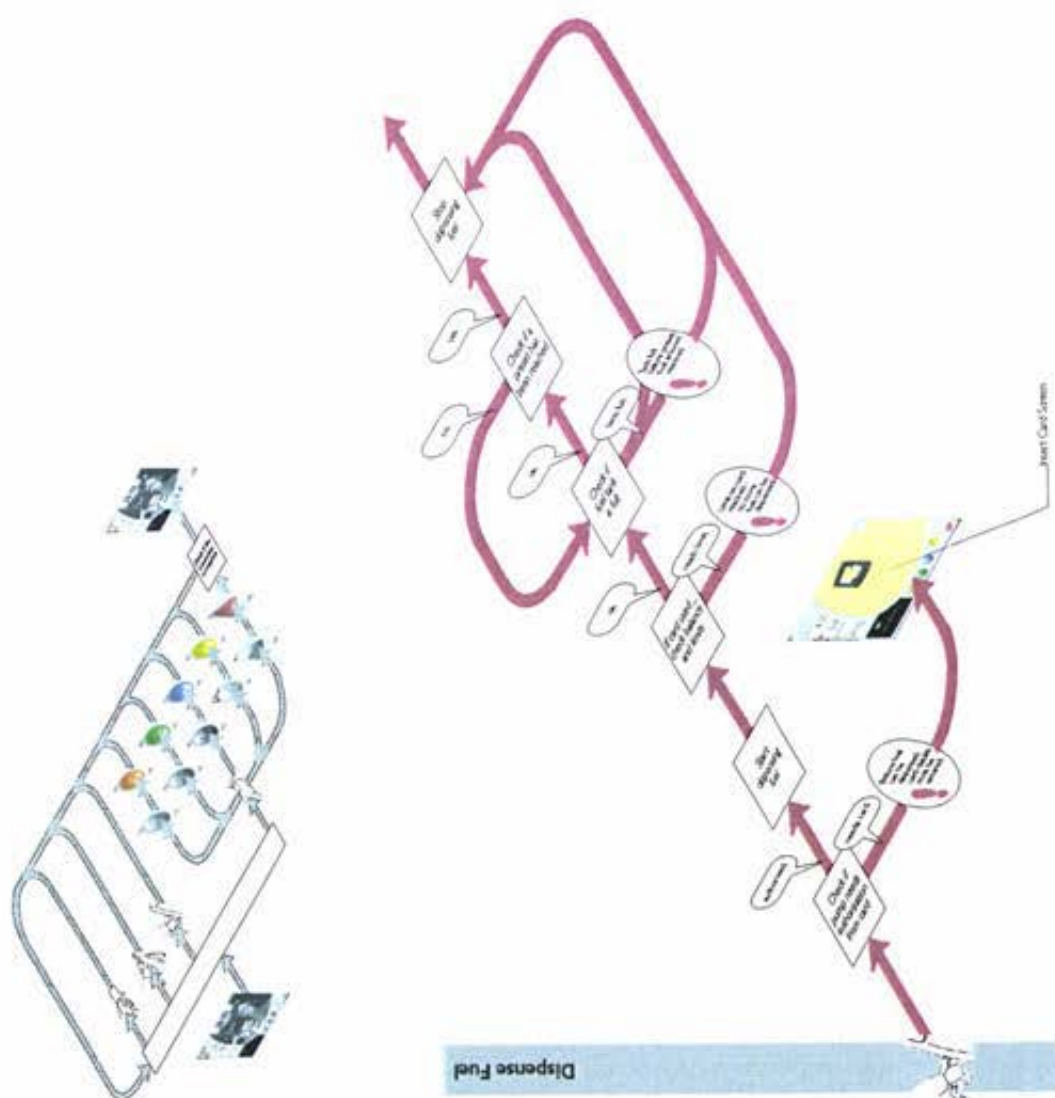


Chart 11.11: Independent User Action - Start Dispensing



Chart 11.12: System Alert Message - Timeout



Chart 11.13: System Alert Message - Error Message

12 Conclusions and Recommendations

The product development process is often presented in a linear and orderly way. In reality the process was observed to be complex and quite fragmented. The theoretical process gives the impression that as one area of work finishes another begins. In practice, however, multiple tasks were always in progress and at different levels of completion.

The first phase of most theoretical product development processes, according to Ulrich and Eppinger (1993); Moore and Pessemier (1995), work towards defining a set of specifications for the product. The specifications are determined through the analysis of competitive products, definition of economic restraint, identification of the needs of the target market, and the definition of needs corresponding to required form, function and features of the product. The target specifications are to be set early in the project and, following the selection of an initial concept, the project team must theoretically be able to commit to specific values of metrics that reflect the product constraints.

The identification of consumer needs is an integral part of the concept development phase of the design process. The resulting identified customer needs guide a project team in establishing product specifications, generating concepts, and selecting concepts for further development. The consumer needs are usually determined from raw data gathered from actual customers (Ulrich and Eppinger, 1993).

In practice, the most useful data was gathered through visual contact with the consumer either in a focus group environment or in an observational study of how the customer used and interacted with a similar product. The developer needed to be aware of all the aspects of a consumer's response as some of the features considered important in the final product were not necessarily articulated by the customer. The customer is advising from the point of what they know, understand, and would like, but often not from a leading edge perspective associated with product innovation.

In a theoretical product development process the product specification is defined and set before most of the design work begins. The specification has a distinct location within the project plan and achieves task completion early into the development process. In practice the desired early task completion was not achievable. While large sections of the specification were able to be accurately set near the start of the project, this was not true for all aspects. Technology is constantly changing and creating new possibilities. Some of the benchmark

technologies available at the commencement of the project had been superseded by the later stages of development. In practice therefore the specification and development were found to occur simultaneously with one providing information for the other.

In the theoretical product specification, all values are quantifiable. The specification is a set of metrics on which everything can be tested and defined (Ulrich and Eppinger, 1993). In practice it was very difficult to quantify all of the values. Current multimedia design does not appear to have recognised quantitative benchmarks from which a realistic product specification could be developed.

From product specifications theoretically come a range of product concepts that meet the identified customer needs. Concept selection or screening follows the concept generation. Practically a range of people were needed to screen concepts, as in some cases an individual had a predetermined expectation of what the product should be. In this situation concepts that did not fit the envisaged mould were often ignored despite having aspects of merit.

Within a theoretical process, product testing is conducted at several stages. Early testing is used to gauge buyer reaction. Ideally testing is repeated whenever the product undergoes a change (Moore and Pessemier, 1995). The process of development and testing is supposedly iterative with the results of product tests used to improve the product to the next prototype stage. In practice, testing at inappropriate stages of the design can be detrimental to the project. Putting excessive emphasis on the testing of a product can curb creativity by knocking out valid solutions before they can be investigated fully. As well, the commercial sensitivity associated with a developing product can often limit the range of potential buyers available from which to seek reaction at various stages.

Traditionally, the first models are created to test technical feasibility. These models are often able to test functions of the final product but may not look anything like it (Moore and Pessemier, 1995). With a multimedia-based product, prototyping is performed using the medium of the final product (ie. The computer screen). The physical interface that the tester communicates with is thus similar if not identical to that which will appear to be being used by the actual system. For this reason it was very difficult to get an evaluator to test the prototype solely in terms of technical feasibility. The initial reaction of the tester was to assume the visual appearance of the screen was representative of the final product, and rather than concentrating on the technical content they became judgemental about the device. The testers were unable to look past the user interface into the desired content. This

was detrimental to the developing product as while no useful feedback was gained, preconceived negative feelings appeared to be emerging towards the project.

To successfully test the individual aspects of a multimedia product the prototyping tool used would need ideally to be different from that of the final product.

During the later stages of development, the multimedia product was able to be successfully prototyped and tested using the medium of the final product and this was found to be invaluable. Trial introductions of the product in conjunction with conducting and analysing consumer research were used to increase the likelihood of customer acceptance.

The types of products that may be sold at the FST are customisable for the individual service stations. Further research will need to be carried out by the service stations to ensure that the products available at the pump are suitable for the location. The FST is intended to improve the flow of customers through a service station. The sale or delivery of inappropriate items at a fuel pump may have a negative effect in this area.

The touch screen interface that has been developed is innovative, technically sound, is inviting to customers and easy to use, allows incorporation of advertising and customisation for use in other countries, meets the companies specifications, and has polled well in consumer tests when incorporated in a simulated mounting.

Published product development techniques which incorporate consumer testing checkpoints throughout discrete phases of product creation were found to be useful in practice, but only if the checkpoints were chosen appropriately and the tests customised for the developing product.

Appropriate timing and tools for the development of a computer human interface were applied throughout the duration of the project at PEC (New Zealand) Ltd.

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Appendix I - Related Technologies Questionnaire and Responses

Questionnaire



MASSEY
UNIVERSITY

Research Project

Fill in this form to be in to win one of two **\$50 petrol vouchers**
(The draw will be made on 1 September 1997 and the winners contacted by phone)

A new user-friendly terminal is currently being designed for use at petrol pumps. The aim of this questionnaire is to identify potential users of the new terminal, and to give people the opportunity to be involved in the development through discussions or trials.



Please indicate your degree of **interest** in each of the following
(TICK ONE BOX FOR EACH OF THE OPTIONS BELOW)

Please indicate which of the following you **use at present**
(TICK ONE BOX FOR EACH OF THE OPTIONS BELOW)

OPTIONS	very	moderately	slightly	not at all	very frequently	frequently	occasionally	not at all
EFTPOS.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
EFTPOS at Service Station.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ATM.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Computer.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Computer based catalogues..... (such as the library catalogue)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Internet.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Self service petrol fill-up.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Automatic snack/drink dispensers.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Drive-through at restaurants.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The following information will be kept strictly confidential

Name: _____

Phone Number: (Hm.) _____ (Wk.) _____

Occupation: _____

I would/would not be interested in taking part in discussions or trials of a new terminal

Responses

Technology	Interest				Use			
	very	moderately	slightly	not at all	very frequently	frequently	occasionally	not at all
eftpos	23	5	0	1	22	7	0	0
eftpos at service station	19	9	0	1	23	3	3	1
atm	10	8	4	8	8	11	4	6
computer	10	6	2	9	9	4	7	10
computer catalogs	6	4	5	14	5	2	6	16
internet	12	3	4	10	6	3	2	19
self service petrol	12	5	2	11	9	4	8	8
automatic dispensers	7	6	8	9	2	2	14	11
drive through	14	4	5	7	7	5	7	10

Appendix ii - Interface Questionnaire and Responses

Questionnaire

Version:

Date:

Introduction:

My name is Katharine O'Driscoll. I am currently working on the Graphical User Interface (GUI) for PEC's new Forecourt Service Terminal (FST mark 3). The FST will comprise of a card reader, a printer, and a touch screen overlaying an LCD screen, and will allow customers to purchase fuel and other products using eftpos or fuel cards at the pump.

The interface prototypes have been modelled using Macromedia Director. The computer keyboard is currently being used to input external information such as picking up a pump. The following commands may be useful when trialing the interface.

- C Insert card (or remove card if a card is already inserted)
- 1 Pick up 91 Unleaded pump (or replace 91 Unleaded pump if the 91 pump is lifted)
- 6 Pick up 96 Unleaded pump (or replace 96 Unleaded pump if the 96 pump is lifted)
- D Pick up Diesel pump (or replace Diesel pump if the Diesel pump is lifted)
- F Start pouring fuel (or stop pouring fuel)
- R Remove receipt

In order to improve the interface I would appreciate your comments.

Please tick the appropriate box

Overall Look:

1. What did you think of the overall appearance of the screens?

☐

OK

☐

Boring

☐

Crowded

☐

Other (please explain)

2. What did you think about the choice of colours?

☐

OK

☐

Too dull

☐

Too bright

☐

Some were acceptable but others weren't (please explain)

Buttons:

1. What did you think of the button sizes?

☐

Too big

☐

About the right size

☐

Too small

☐

Some were acceptable but others weren't (please explain)

2. What did you think about the button placement?

☐

Acceptable

☐

Too close together

☐

Other (please explain)

Content:

1. Did the FST allow you to do everything that you expected?

☐

Yes

☐

No (please explain)

☐

Allowed you to do more than is necessary (please explain which events are surplus to requirement)

2. Did you know what to do when first viewing the FST Interface?

☐

Yes – knew straight away

☐

Was able to work out what to do

☐

Required additional help (please explain where the extra help was needed)

☐

Didn't know what to do (please explain)

Navigation:

1. Were you able to find your way through the Interface screens?

☐

Yes – knew straight away

☐

Yes – after 1 try

☐

Yes – after it was explained

☐

No (please explain)

Flow:

1. How did you find the flow of events?

☐

Logical – easy to follow

☐

Got a bit lost

☐

Couldn't follow it – got completely lost (please explain)

Usage:

1. Would you use the FST mark 3 in a service station?

☐

Yes

☐

Maybe

☐

No (please explain)

Comments:

Do you have any other comments?

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. The paper appears to be a standard notebook page or a sheet of stationery designed for writing.

Thank you for your time

Responses

Section 1: Overall Look

					Comments
1. What did you think of the overall appearance of the screens?	OK	Boring	Crowded	Other	Great. Perhaps the text could be darker. Label the buttons to give the user some indication of what they are for. Colours are a bit bland.
	7			5	Great – love icons, not overcrowded, like soft lines & curves. Is there any significance to colour of icons, e.g. Pump – orange? Touch screen or swipe card. Ragged edges on curve. I am not sure about the icons being different heights. Do you need the pump total there at all time. Insert card graphic should just show inserting card. I don't like the watch icon during the card approval screen. There should be a way of cancel. The information box needs to be highlighted. Icon changes as soon as preset button has been pressed. Good. Very "state of the art". "Remove receipt" screen is cruder than rest – what about dropping the red arrow and having a better moving receipt. I like it. Really neat – especially the curved one.
2. What did you think about the choice of colour?	OK	Too dull	Too bright	Some acceptable	Excellent – very friendly. Background colours are rather pale. Perhaps not pink. Liked colours – how do they look outside. I think they would have to be brighter in the outdoors.
	9			3	On the whole I liked the colours but thought the pink wasn't complimentary. Liked the colour changes to the 4 round buttons. Colour Blind can they see these colours.

Section 2: Buttons

Comments				
1. What did you think of the button sizes?	Too big	About right size	Too small	Some acceptable
		11	1	1
<p><i>Some buttons need labeling to indicate their purpose.</i></p> <p><i>Buttons need to be 18mm² min.</i></p> <p><i>Draft ISO std for touch screen suggests a button size of at least 1 sq cm.</i></p> <p><i>PLU buttons bit big – other I liked especially the 4 round ones.</i></p> <p><i>Particularly like the general merchandise bars.</i></p>				
2. What did you think about the button placement?	Acceptable	Too close	Other	
	11	1	1	
<p><i>Perhaps if they were labeled it would be friendlier.</i></p> <p><i>The other purchases menu buttons need re-sizing to fit in screen area.</i></p> <p><i>Buttons need to be 18mm² min.</i></p> <p><i>The order of buttons needs changing. Card first and other three separate in order (fuel, car, shopping basket). Card details have to be entered – so why have it as an option? – The card details is not an option – it is simply a status indicator.</i></p> <p><i>PLU ones a bit close perhaps.</i></p>				

Section 3: Contents

Comments				
1. Did the FST allow you to do everything that you expected?	Yes	No	More	
	9	2	1	
<p><i>The menu didn't work.</i></p> <p><i>Oil selection hung.</i></p> <p><i>Like incorporating pump display. (Although don't know how we are going to do it.)</i></p> <p><i>But can't review sale as you are going.</i></p> <p><i>Had to press ok when I pressed the fill button.</i></p>				
2. Did you know what to do when first viewing the FST interface?	Straight away	Able to work out	Required help	Didn't know
	2	8	2	
<p><i>More instructions in lower left screen.</i></p> <p><i>Would be much easier with real model.</i></p> <p><i>Computer/technology illiterate may be nervous as to where to start, i.e. If they press the wrong one where will they end up.</i></p> <p><i>Worked out that I could press the buttons but didn't know I could press the screen anywhere to enter fuel.</i></p> <p><i>I am generally a bit of a duffer with mechanical things & got a bit confused with keyboard and mouse functions in test. If all touch screen this would not occur.</i></p>				

Section 4: Navigation

Comments				
1. Were you able to find your way through the interface screens?	Straight away	After I try	After explanation	No
	3	8	1	
<i>After playing for a while. Need more helpful instructions either on the buttons or in lower left screen.</i> <i>But I felt that other people might get lost.</i> <i>Would be much easier with model.</i> <i>Bit unsure of what exit did within each screen.</i>				

Section 5: Flow

Comments				
1. How did you find the flow of events?	Logical	Got a bit lost	Couldn't follow	
	1	5		
<i>Active icons need to be brighter. Car wash/oil selection no obvious what to do.</i> <i>Needs a real setup to really get good feedback on flow.</i> <i>Help messages in black area could be used to help even further.</i>				

Section 6: Usage

Comments				
1. Would you use the FST mark 3 in a service station?	Yes	Maybe	No	
	8	3		
<i>If it worked...</i> <i>The only time I think I wouldn't is if I thought the pump might leak and make my hands smell if I am going to work. If some "helpful" chappy was looking over my shoulder I'd get flustered & refuse to use it. Don't want anyone to see my PIN number either.</i>				

Section 7: Comments

Do you have any other comments?

After fuelling, perhaps the user should be prompted. If you have never used it you would not know what to do. Perhaps label the icons. Make the timeout less. Change the EXIT button to – finalise sale.

The sweep is good. Nice and graphical.

The watch display during fuelling does not mean anything. Either indicate what is happening, just dispensing, EFT transaction, or what!!

Sequence of events seems strange. Select an amount of fuel, insert nozzle and start filling. Insert card & enter details. Remove nozzle (stop pumping). Processing & then remove card – this is the bit that seems odd. I can now add miscellaneous items to the total account \$ but I've taken my card out! Is this ok? I just thought I shouldn't be able to remove card until transaction finalised! If people need to re-enter info, eg. Incorrectly entered PIN, it took me a while to notice the message in the black screen – need to emphasise – need to re-enter info, eg. Change colour of ? screen. Need message – if finished press exit to print receipt.

You can get a state in which the system is asking for the fuel amount. If you don't want fuel, there is no way out – car/shopping options are disabled.

Cents per litre should not disappear when you stow pump nozzle. Conventional operation should be allowed (ie. Operate just as if there was no FST) – at the moment it gets stuck at end of delivery. Like prompting for car wash/oil/valvemaster after delivery – should timeout be quicker (Otherwise next customer will fill on my card). Show trailing zeros on dollars and litres. Why is exit button live on startup screen? Grey out PIN entry screen.

Exit button – not really obvious of its function. Can't review what items are within a sale during a sale. Love the shape of the "oval" for advertising & sale information etc. Oil company may want more than their embossed logo icon on the main screen. Looking good.

What about translation requirements? – ie. Left to right languages etc. What about reactions from other cultures.

I thought this was incredibly interesting. I felt I might impulse buy other things just to try out the system. How would I get my car wash, chitty, my oil etc? Would someone rush out with it?, a machine pop it out?, or would I pick it up at the drive by window o the way out?, or go to shop and present receipt and get given the goods? I really didn't notice the colours, size of buttons etc – If I had been frustrated by them I would have. The random change of the ads is a little disconcerting while you are concentrating on the other things you are doing. Can ignore after you've looked to see what's there.

Appendix iii - Interface Component Results

Icons

Tester	Pump Icon	Card Icon	Car Icon	Other Icon	Finish Icon	End Word
1	pump	credit cards	car	trolley	tick	
2	pump	card	oil can	trolley	register	
3	pump	card	oil can	trolley	receipt	
4	nozzle	hand pointing	car	trolley	tick	
5	pump	dollar sign	car bonnet up	snack food	arrow	
6	pump	credit cards	car bonnet up	trolley	dollar sign	
7	pump	card	oil can	holding money	tick	
8	pump	vending	car	register	tick	
9	pump	card	car	trolley	dollar sign	
10	nozzle in circle	card	car bonnet up	trolley	tick	finish
11	pump	card	car bonnet up	trolley	tick	exit
12	pump	card	car bonnet up	trolley	stop sign	done
13	pump	card	car	trolley	tick	done
14	pump	card	car	trolley	register	exit
15	car	card	car bonnet up	trolley	receipt	done
16	pump	card	car	trolley	receipt	done
17	drop in tank	credit cards	car	trolley	register	done
18	pump	card	tyre	vending	dollar sign	done
19	pump	card	car	trolley	receipt	end
20	pump	card	tyre	trolley	tick	finish
21	nozzle	key pad	car	trolley	tick	done
22	pump	holding money	car	trolley	register	finish
23	pump	card	car	grocery bag	receipt	finish
24	nozzle	card	car	trolley	tick	end
25	pump	card	car	trolley	receipt	done
26	pump	card	car	trolley	tick	done
27	pump	card	car	trolley	tick	done
28	pump	card	car	trolley	tick	done

Button Sizes and Spaces

Tester	Square		Rectangle		Triangle		Circle	
	Size	Space	Size	Space	Size	Space	Size	Space
1	60	15	50	10	60	10	60	5
2	50	0	50	5	50	5	50	0
3	60	15	60	10	70	10	60	10
4	60	5	60	5	60	5	60	5
5	70	5	50	0	60	0	50	0
6	60	0	60	0	60	0	60	0
7	40	5	50	5	50	5	50	5
8	50	0	50	0	50	5	60	0
9	70	5	60	5	70	5	70	5
10	50	5	40	10	60	5	60	5
11	70	15	50	15	70	10	50	10
12	50	0	60	5	50	5	50	0
13	40	5	40	5	40	10	40	5
14	60	5	60	5	60	5	60	5
15	50	20	60	20	50	20	60	20
16	50	5	50	5	50	5	50	5
17	80	5	80	5	80	5	80	5
18	40	10	50	10	50	10	60	10
19	70	5	80	5	70	5	70	5
20	50	0	40	0	40	0	40	0
21	40	0	40	0	40	0	40	0
22	60	15	60	10	60	10	60	10
23	40	10	40	10	40	10	40	10
24	50	0	50	0	50	0	50	0
25	90	20	90	20	80	15	80	15

Button Size	Square	Rectangle	Triangle	Circle
40	5	5	4	4
50	8	9	8	7
60	6	8	7	10
70	4	0	4	2
80	1	2	2	2
90	1	1	0	0
100	0	0	0	0

Button Spacing	Square	Rectangle	Triangle	Circle
0	7	6	5	8
5	10	10	11	10
10	2	6	7	5
15	4	1	1	1
20	2	2	1	1

Appendix iv - Formal Questionnaire and Responses

Questionnaire

PEC Forecourt Service Terminal

Interface Questionnaire

My name is Katharine O'Driscoll; I am a Masters student in Technology at Massey University. Over the past 12 months I have been working with PEC on the development of a touch screen interface for the next generation of EFTPOS at the pump.

Thank you for taking the time to participate in the testing of the new forecourt service terminal interface. Your responses to the questions will help to insure that the interface which goes into production will look, work, react, and contain what you, the consumer, expects and wants from the system.

Section 1: Introduction

When using the system did you experience problems with any of the following:

	No problems				Major problems	Comments
1. Working out how to use the system?						
2. Understanding how to carry out the tasks?						
3. Knowing what to do next?						
4. Understanding how the information on screen relates to what you are doing?						
5. Finding the information you want?						
6. Information which is difficult to read clearly?						
7. Too many colours on the screen?						
8. Colours which are difficult to look at for any length of time?						
9. Being able to do things the way you wanted?						
10. Losing track of where you are in the system or of what you are doing or have done?						
11. Unexpected actions by the system?						
12. The touch screen being difficult or awkward to use?						
13. Having to spend too much time inputting information?						
14. Having to be very careful to avoid errors?						
15. Working out how to correct errors?						
16. Having to carry out the same type of activity in different ways?						
17. Feeling confident about the system being secure?						
18. System errors or malfunctions?						

Section 2: Detail

The way the system looks and works should be consistent at all times, while the information displayed on the screen should be clear, well organised, unambiguous and easy to read.

	<div> <div>Always</div> <div> </div> <div>Never</div> </div>					Comments
1. When entering information on the screen, is it clear:						
a) Where the information should be entered?						
b) In what format it should be entered?						
2. Does information appear to be organised logically on the screen?						
3. Are different types of information clearly separated from each other on the screen?						
4. Does the use of colour help to make the displays clear?						
5. Are the different colours used consistently throughout the system?						
6. Is the clarity of information on the screens satisfactory?						
7. Are icons, symbols, graphical representations and other pictorial information used consistently throughout the system?						
8. Is the same type of information (e.g. instructions, messages, pictures) displayed consistently:						
a) In the same location on the screen?						
b) In the same layout?						
9. Is the way the system responds to a particular action consistent at all times?						
10. Are messages displayed by the system relevant?						
11. Is it clear what actions you can take at any stage?						
12. Does the system clearly and promptly inform you when it detects an error?						

	<div style="display: flex; align-items: center; justify-content: space-between;"> Always Never </div>					Comments
13. Do error messages explain clearly:						
a) What the errors are and why they occurred?						
b) How to correct the errors?						
14. Is there an easy way to 'undo' an action and step back to a previous stage or screen?						

15. Are there any comments (good or bad) that you wish to add regarding the above issues?

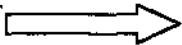
16. Overall, how would you rate the system in terms of detail?
(Please tick the appropriate box below)

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory

Section 3: Expectations

The way the system looks and works should meet with user expectations.

	<div style="display: flex; align-items: center; justify-content: space-between;"> Always Never </div>					Comments
1. Are colours assigned according to conventional associations where these are important?						
2. Where icons, symbols, graphical representations and other pictorial information are displayed:						
a) Are they easy to recognise and understand?						
b) Do they follow conventions where these exist?						
3. Is information entered into the system displayed in the way you expected?						

	Always					Never	Comments
4. Are established conventions followed for the format in which particular types of information are displayed? (e.g. pin numbers, key pads)							
5. Does the sequence of activities required to complete a task follow what you would expect?							
6. Is the touch screen appropriate for the tasks to be carried out?							
7. Is the way in which information is presented appropriate for the tasks?							
8. Does each screen contain all the information that is required to carry out a task?							
9. Are you provided with all the options necessary at any particular stage in a task?							
10. Does the system work in the way you think it should work?							
11. Can you move to different parts of the system as required?							
12. Is it clear what part of the system you are in?							
13. Is it clear what the different parts of the system do?							
14. Is the system well organised from the user's point of view?							
15. In general, is it clear what the system is doing?							

16. Are there any comments (good or bad) that you wish to add regarding the above issues?

17. Overall, how would you rate the system in terms of expectation?
(Please tick the appropriate box below)

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory

Section 4: General

Please give your views on the usability of the system by answering the questions below in the spaces provided. There are no right or wrong answers.

1. What are the best aspects of the system for the user?
2. What are the worst aspects of the system for the user?
3. Are there any parts of the system that you found confusing or difficult to understand?
4. Were there any aspects of the system that you found particularly irritating although they may not have caused major problems?

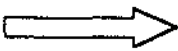
5. What were the most common difficulties you encountered when using the system?
6. What changes would you make to the system to make it better from your point of view?
7. Would you like to see this system on a forecourt in a service station?
8. Is there anything about the system you would like to add?

Results

Section 1: Introduction

When using the system did you experience problems with any of the following:


	<div style="display: flex; align-items: center; justify-content: space-between;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">No problems</div> <div style="font-size: 2em;">→</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Major problems</div> </div>					Comments
1. Working out how to use the system?	1	14	4	0	1	After two transactions I started to feel comfortable. Took a while to "click". Something new & different. One or two minor confusions. Oil menu button not clear regarding function. Text in bottom corner small
2. Understanding how to carry out the tasks?	4	11	3	2	0	Knowing where the objects are. Ending a sale unclear.
3. Knowing what to do next?	1	9	5	2	0	No problems after first time. Receipt open when went to fuel & still overlays screen but doesn't say how to remove.
4. Understanding how the information on screen relates to what you are doing?	14	5	1	0	0	
5. Finding the information you want?	6	8	4	2	0	Knowing where the objects are. Sub menus take some searching.
6. Information which is difficult to read clearly?	10	7	1	1	0	Very clear. Product names too small. Very easy to read. Text in black box small but critical.
7. Too many colours on the screen?	19	0	0	0	0	Good balance. One of the best aspects. Too much on screen. Looks nice. Very easy to read. Text in black box small but critical.

	<div style="display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">No problems</div> <div style="margin: 0 10px;">  </div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Major problems</div> </div>					Comments
8. Colours which are difficult to look at for any length of time?	19	0	0	0	0	<i>Looks nice.</i>
9. Being able to do things the way you wanted?	7	7	2	2	1	<i>Mouse not calibrated</i> <i>Fuel purchase - could not get past entering card details. No fuel was pumped. Instructions did not say to push button.</i> <i>Alignment of finger.</i> <i>Fuel card option.</i>
10. Losing track of where you are in the system or of what you are doing or have done?	9	5	4	1	1	<i>No evidence to tell what has been sold summary.</i> <i>View receipt always available but not always prompted.</i>
11. Unexpected actions by the system?	11	5	0	2	0	<i>When finishing payment entry a product menu appeared. I interpreted this as a request to review the product selection even though I thought I had just paid.</i> <i>On the last shopping list I viewed my receipt half way through the transaction. When I came to select the account to use the receipt popped back up and covered the buttons.</i> <i>"- -" at some time know what response.</i> <i>Car wash number - see later.</i>
12. The touch screen being difficult or awkward to use?	5	9	4	1	0	<i>Mouse not calibrated.</i> <i>Finger seemed to hit button below.</i> <i>VDU too far back from the touch screen.</i> <i>Too sensitive.</i> <i>Due to my height.</i> <i>Numeric pad should be bigger.</i> <i>The screen "beeps" even when I missed the key. Was confusing when entering PIN's for example - had to check screen to see if I had really hit the key or not.</i> <i>Distance of glass.</i> <i>Minor parallax issue, but I accept it is a demo problem.</i> <i>Keyboard for rego.</i>

	<div style="display: flex; align-items: center; justify-content: space-between;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">No problems</div> <div style="font-size: 2em;">→</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Major problems</div> </div>					Comments
13. Having to spend too much time inputting information?	9	9	1	0	0	<i>Slow for a start.</i> <i>Searching for products.</i>
14. Having to be very careful to avoid errors?	6	7	3	3	1	<i>add/delete not intuitive. How to correct an item - i.e. coke * 3.</i> <i>Because of 12.</i> <i>Can't backspace.</i> <i>Keyboard for rego.</i>
15. Working out how to correct errors?	7	7	3	3	0	<i>No backspace. Leaving out the backspace for the Qwerty keyboard means complete reentry on a mistake.</i> <i>Fuel card.</i> <i>Delete items button took a minute to work out, everything else ok.</i>
16. Having to carry out the same type of activity in different ways?	12	6	0	0	0	<i>Thought it was quite consistent.</i>
17. Feeling confident about the system being secure?	16	3	0	0	0	<i>Could be an issue.</i> <i>Is anything really that secure anyway?</i>
18. System errors or malfunctions?	14	2	2	1	0	<i>No - but a backwards button would be good. Also a cancel button might be appropriate.</i> <i>On the last shopping list I viewed my receipt half way through the transaction. When I came to select the account to use the receipt popped back up and covered the buttons.</i> <i>A couple of minor suggestions, see later.</i> <i>Didn't have any.</i>

Section 2: Detail

The way the system looks and works should be consistent at all times, while the information displayed on the screen should be clear, well organised, unambiguous and easy to read.

		<div> <div>Always</div> <div>  </div> <div>Never</div> </div>					Comments
1.	When entering information on the screen, is it clear:						
	a) Where the information should be entered?	6	13	1	0	0	<i>PIN entry confusing because numbers look greyed out.</i> <i>Once the concepts are "grasped".</i> <i>Not always sure where to find things.</i> <i>one or two minor suggestions, see later.</i> <i>"+ & -" for quantity good but not 100% intuitive.</i>
	b) In what format it should be entered?	13	6	0	0	0	
2.	Does information appear to be organised logically on the screen?	10	9	1	0	0	<i>The menu for shopping cart seems to have two levels. Make this all tab driven and one level only. Traversing trees is boring.</i> <i>Some confusion on knowing where to find it.</i> <i>"+ & -" for quantity good but not 100% intuitive.</i>
3.	Are different types of information clearly separated from each other on the screen?	14	6	0	0	0	
4.	Does the use of colour help to make the displays clear?	17	3	0	0	0	<i>Particularly liked the layout, colours and clarity of text.</i>
5.	Are the different colours used consistently throughout the system?	13	6	0	0	0	<i>I have no problems.</i>
6.	Is the clarity of information on the screens satisfactory?	5	8	4	2	0	<i>Perhaps have a few sentences explaining what to do, e.g. Examples.</i> <i>Text + icon is probably clearer.</i> <i>When shopping for some items, it was hard to pick the correct one because I was not familiar with the colour and logo of the product.</i> <i>Instructions critical but not always highlighted.</i>
7.	Are icons, symbols, graphical representations and other pictorial information used consistently throughout the system?	14	6	0	0	0	
8.	Is the same type of information (e.g. instructions, messages, pictures) displayed consistently:						
	a) In the same location on the screen?	14	5	0	0	0	<i>I found instructions on screen not always blatantly obvious.</i>
	b) In the same layout?	14	4	0	0	0	

	<div style="display: flex; align-items: center; justify-content: space-between;"> Always → Never </div>					Comments
9. Is the way the system responds to a particular action consistent at all times?	15	4	0	0	0	<i>When filling or buying only visual confirmation given.</i>
10. Are messages displayed by the system relevant?	8	9	2	0	0	<i>One or two minor suggestions, see later.</i> <i>Receipt message not always displayed.</i>
11. Is it clear what actions you can take at any stage?	4	4	8	2	2	<i>Got lost looking for the petrol pump nozzle. Took a while to realise to push the button instead.</i> <i>It was not clear to me that the "bye" button was more like a "buy" button. I was worried that pressing the bye button would terminate my selections.</i> <i>Receipt message not always displayed & enter card.</i>
12. Does the system clearly and promptly inform you when it detects an error?	6	3	1	2	1	<i>Don't know didn't have an error.</i> <i>Don't know, didn't generate any.</i> <i>Because no sale window not show when you are in a sale.</i> <i>Didn't see any error messages.</i> <i>Oops. Was I supposed to make errors?</i> <i>No errors.</i>
13. Do error messages explain clearly:						
a) What the errors are and why they occurred?	8	3	1	0	0	<i>Didn't get any.</i> <i>No errors.</i>
b) How to correct the errors?	6	4	2	0	0	
14. Is there an easy way to 'undo' an action and step back to a previous stage or screen?	2	2	7	4	1	<i>Didn't try.</i> <i>Rego number.</i> <i>?</i> <i>Didn't have to.</i> <i>Particularly at keyboard.</i>

15. Are there any comments (good or bad) that you wish to add regarding the above issues?

I think this is excellent and would work well with a proper petrol pump instead of confusing me by putting a button in instead.

There was no "end" button - I thought I would get a "confirmation".

Was unsure on completion of purchases, what to do.

Confirmation of purchases could be clearer i.e.. It is still difficult to know that you have actually brought an item.

I particularly liked the graphics, colours, and size of buttons and text. Everything was very clear and easy to read.

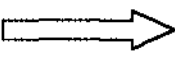
In the size of oil pack menu the oil menu button is not intuitively named. The receipt up on the screen when the next function performed ? no message how to clear receipt.

16. Overall, how would you rate the system in terms of detail?
(Please tick the appropriate box below)

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory
11	6	1	0	0

Section 3: Expectations

The way the system looks and works should meet with user expectations.

	<div style="display: flex; align-items: center; justify-content: space-between;"> Always  Never </div>					Comments
1. Are colours assigned according to conventional associations where these are important?	10	8	1	0	0	<i>From my perspective no problems.</i>
2. Where icons, symbols, graphical representations and other pictorial information are displayed:						
a) Are they easy to recognise and understand?	10	4	3	2	1	<i>When shopping for some items, it was hard to pick the correct one because I was not familiar with the colour and logo of the product.</i> <i>Not sure about car wash symbols otherwise ok.</i> <i>Not obvious that icons at the top of the oil, car wash etc. shopping pages are actually buttons.</i>
b) Do they follow conventions where these exist?	11	7	0	0	0	
3. Is information entered into the system displayed in the way you expected?	8	8	2	0	0	<i>Ok.</i> <i>No expectations.</i>
4. Are established conventions followed for the format in which particular types of information are displayed? (e.g. pin numbers, key pads)	12	6	2	0	0	<i>PIN number entry numbers need to be darker grey.</i> <i>Ok</i> <i>"+" buttons rather than add / delete switch, see later.</i> <i>Fill key. Del key on keyboard.</i> <i>Keyboard missing backspace key.</i>
5. Does the sequence of activities required to complete a task follow what you would expect?	5	9	3	2	0	<i>I thought I would get Are you sure.</i> <i>ok.</i> <i>Room for variation while still functioning.</i>

	<div style="display: flex; align-items: center; justify-content: space-between;"> Always → Never </div>					Comments
6. Is the touch screen appropriate for the tasks to be carried out?	16	4	0	0	0	Miss keyed a few times. ok. Could be difficult for people with limited dexterity. Definitely.
7. Is the way in which information is presented appropriate for the tasks?	6	11	1	1	0	
8. Does each screen contain all the information that is required to carry out a task?	10	4	5	1	0	Knowing where to find things. Not sure how to proceed at some points. The instructions are not "idiot proof". Some small confusion for first time through on where to find. Receipt on screen prompt.
9. Are you provided with all the options necessary at any particular stage in a task?	8	8	2	2	0	"Back out" button. Payment in the end. Receipt on screen prompt.
10. Does the system work in the way you think it should work?	9	9	0	1	0	
11. Can you move to different parts of the system as required?	16	4	0	0	0	Once I found where it all was.
12. Is it clear what part of the system you are in?	11	7	2	0	0	Yes, but it would be nice to know your sale total. Sub menus in products could be difficult.
13. Is it clear what the different parts of the system do?	9	7	2	1	1	
14. Is the system well organised from the user's point of view?	7	9	3	1	0	
15. In general, is it clear what the system is doing?	7	9	3	1	0	

16. Are there any comments (good or bad) that you wish to add regarding the above issues?

It was fun, once familiar it was easier the 2nd time. I expected more checks & confirmation.

Some points after keying information, am unsure if system has processed information. Left me thinking - have I missed something.

Good graphical interface. It would be nice to have a running total of what makes up the sale.

Once you have familiarised yourself with the system it is good, but the initial use is a matter of trial and error & can be confusing.

I did have to stop and think for awhile on the first shopping list on where to find things. No problems on subsequent shopping lists. However, this initial confusion may stop many people exploring the system in a live situation.

17. Overall, how would you rate the system in terms of expectation?
(Please tick the appropriate box below)

Very satisfactory	Moderately satisfactory	Neutral	Moderately unsatisfactory	Very unsatisfactory
9	6	3	0	0

Section 4: General

Please give your views on the usability of the system by answering the questions below in the spaces provided. There are no right or wrong answers.

1. What are the best aspects of the system for the user?

Simple interface, clear & obvious what to do & how to do it.

Easy to use logical steps to follow to do simple tasks.

The screen is uncluttered. The icons & graphics provided are crisp, clear & to the point. Very intuitive.

Quick & fun.

Touch screen is a lot more natural than off screen buttons. Big buttons bold colours make it easy to identify different things on screen.

Being able to get everything you need & paid for without waiting around.

Being prompted with visual images of products.

Pleasant to use.

Colourful - Friendly - Hi tech - Almost like a game.

Nicely organised.

Comprehensive services. Provided that delivery of the services is as easy as the ordering. For example, buying chocolate is easy if it is dispensed at the same place it is ordered.

Once mastered is easy and flexible to use.

Clear graphical interface. Good colour combination.

No queues in shop.

Icons are recognisable. Once the system becomes familiar it is easy to follow. On screen instructions brief & to the point.

The visual appearance, use of colours, use of easy to recognise symbols, good size buttons and text easy to read. The novel organisation of the screen, especially the "oval" shape.

Simple, easy to use once you know what all the icons mean.

Looks elegant, simple & inviting

2. What are the worst aspects of the system for the user?

I thought that I selected the grade of fuel on the FST screen rather than on the pump.

Having to stand up straight and face the panel instead of lean on the wall!

What you have to do. I think the step of when you have finished buying fuel & items is not quite as intuitive as the rest of the process. I finally clicked on the card icon as after some thought it seemed to only option left. I wasn't sure when to click the bye icon.

The confirmation of your transaction either at purchasing time or payment.

The touch screen is not flat on the VDU screen, the extra distance makes it difficult to line up on buttons at times.

Miss keying - but then that happens on physical keys as well.

The process of adding "shopping items". Once I had pushed a button I would have expected it to have been purchased.

There was no information about where to collect the chocolate (or oil or valvemaster for that matter).

Needs better prompting - maybe a greeting screen highlighting various areas.

Use of "bye" to end sale - why not "finish" as in PC

Standing on forecourt in rain & wind "pushing buttons".

Initial use confusing. Confirmation of purchases is not obvious - i.e., You have to look hard to see if you have brought anything.

The startup information. The prompt "touch screen for service" defaults to the fuelling screen. It wasn't immediately obvious that all the other screens were available. Maybe the initial prompt should direct users to the four screen selection buttons on the right to make them aware of the fact that there are four screens.

Instructions don't stand out. The instruction box should flash. If you are paying instore you don't want to have to come back to the FST after filling with petrol, you want to be able to go straight to the store.

Sub menus. Small instruction text.

3. Are there any parts of the system that you found confusing or difficult to understand?

No.

Just got a bit confused when I had to push the button instead of lift the nozzle.

The icon, e.g. car wash & I didn't know what valvemaster was. Drinks was a good guess.

The concept of switching from fuel to other purchase while filling petrol is not immediate obvious.

When it came to shopping, only looked at buttons at top of screen for snacks etc. Didn't realise the bottom buttons 1-4 were included in the selection.

When asking for PIN, should say "CHEQUE pin" like other eftpos systems. After selecting COKE, no prompt as to how to proceed - perhaps a prompt in black area ("make another selection") or come back to flashing arrow?

Finding where to go for different things i.e., Oil wasn't clear to start with.

When to pay.

No.

Took me a while to figure out how to access needed parts of the system.

Finding where the PLU's are when not on screen which screen are they.

No.

I was unable to use the fuel card option - perhaps it needs an instruction menu for the different payment methods.

The paging system on each screen (the first time through). Icons at the top weren't obviously buttons. Maybe add the word page to the 1 of 4 selection. Not selecting fuel grade. I thought you had to (or should have to) push the fuel grade icon. Having to push "bye" to complete transaction. Maybe change to something more obvious like end, finish?

The icons - shopping and car.

No, but it was familiar when started.

4. Were there any aspects of the system that you found particularly irritating although they may not have caused major problems?

No.

No.

Is there a "help" key?

Hitting appropriate keys.

I found the icons may be a bit small. Like entering numbers, or letters mainly due to the angle I was viewing from, and not knowing whether I hit the right key until it actioned.

Lack of confirmation of actions at each step (for the very dumb like myself).

Once the receipt was up, it covered the account select buttons.

No.

Putting in first pin number - many times to get it right.

Small buttons on rego input.

Having to come back after pumping gas, prefer to use the FST completely before pumping gas.

5. What were the most common difficulties you encountered when using the system?

Problems with the calibration of the screen. Quite easy to 'miss' the button

None.

Having to hit above the button not on it. Prototype problem.

Pressing the keypad.

Being able to hit the correct "buttons".

Step by step confirmation of my actions.

None.

Right spot to put finger.

Pushing wrong button.

Not sure if I had done the correct thing.

A couple of minor confusions on the first time through. After the initial learning period it was very easy to use. Confusion detailed under #3.

The system never took you anywhere, the user has to direct it, you should be prompted questions and have to answer them about buying confectionery & oil or car wash.

Idiot operator.

6. What changes would you make to the system to make it better from your point of view?

None.

Make the screens not so busy, a little clearer or prompting on next step.

Advertise its potential while dispensing fuel. - presently it just greys out - use this space to explain other features of the system.

Confirmation.

Make it clearer how to pay.

Make keypads bigger.

A one or two screen "system preview"?? Beep only when button is "hit".

Proper touch screen to input. Perhaps "finish" to close sale.

None.

More obvious confirmation of purchase, either visual or audio instructions at beginning of payment methods.

Add some form of on-line help system. Something like help, coach, wizard commonly used in software. Audio feedback on touch screen should be restricted to parts of the screen where valid selection can be made. If you push something that is just for looking at it shouldn't beep. Once fuel delivery complete the enter preset prompt should change to view receipt prompt. One fuel sale per transaction is most likely so the preset prompt doesn't need to stay. I would consider changing the add item / delete item switch. More of a standard to use + - buttons on each item? It may be more obvious to some people.

Have the FST lead you through the system.

7. Would you like to see this system on a forecourt in a service station?

YES

Yes.

YES! I would like to see something similar for a console too!

Yes.

Yes.

I think there may be a bit of confusion to start with but otherwise people may find it preferable.

Absolutely!

Yes.

Yes.

Yes!

Yes.

Service station.

Yes.

Yes. Definitely.

Yes.

100's of 1000's of forecourt's - urgently!!

8. Is there anything about the system you would like to add?

Great interface - much better than PEPSI - Great to see user testing. Please set it up at the Park and Hair St for testing.

Be a money machine as well.

On fuel menu, above unld 91, 96, Die - put Current Fuel Prices. Instead of "bye" - next - Also incorporate a CANCEL button. The payment bit was the hardest to understand. Perhaps you should used the word "Pay" under the card logo. Can't go over \$99. Once you have selected an amount you can still press fill and it will fill your tank. Instead of the advertising on the first screen, perhaps the name of the service station. Height - too low for me.

After fuel sale - should say please pay - instore or card, rather than "please select preset". Presently you have to press bye - which is not what you want to do if you are going to pay by card.

When Pin incorrect no obvious place to touch. Did not notice "Pay in shop" could not get back out. Thought the "add item" had to be touched after amount entered. After list 2 was not obvious to touch "bye" again. I thought the list of fuels had to be touched for the right one.

Change - cash perhaps. Shopping list 1 - Selected the "gas icon" & then \$20.00 then the "91" to the right corner of the screen. There was no indication I had selected - I think because I forgot to put the nozzle in the car. Numeric keys a little too close perhaps - got 3 when I tried to select 2. Shopping list 2 - Missed a few keys i.e. hit key next to one I was aiming for. A little unsure as to what I actually paid for until I saw the receipt menu bottom left. Shopping list 3 - No verification that system would "fill" the tank after pressing "fill tank". Pay instore - easy pesy. I'm getting the hang of this! Shopping list 4 - I like it! Again I must have hit a wrong number - the arrow that appears when you hit the button is usually obscured by your finger. Perhaps if the key pressed was to darken or lighten instead. I realise it should not be too obvious to other eyes.

It is hard to review what you have selected before you pay. Perhaps a shopping basket view with petrol and other products purchased would be handy. This would help avoid accidental purchases.

No. Entering rego number shopping list 2, clear last number not whole thing. Receipt writing too small.

Options menu at start. Options for payment type before filling. Fuel card difficulties. System not total self explanatory. Quit / clear / get me out of here. Receipt difficult to read.

Bug in car wash number. Every time you view receipt (on the same sale) the car wash number changes. Generally very impressed. Good work. Well done.

No.

When you select to pay instore you have no record of your transaction. It would be nice to get something like a transaction record that has a barcode on it, so that when you go into the store you can present this, have it scanned & your sale is automatically located and brought up on the POS.

Appendix v - Interface Testing Results

List I

Tester Number	Start Time	Finish Time	List I					Time Taken	Errors
			Card	\$20 91	Deluxe Car Wash	Coke	Extra Purchase		
1	11:12:16	11:14:40	1	1	1	1	0	0:02:24	0
2	11:24:16	11:27:19	1	0.5	1	1	0	0:03:03	0.5
3									
4	14:52:09	14:54:59	1	1	1	1	0	0:02:50	0
5	20:59:29	21:01:34	0	1	1	1	0	0:02:05	1
6	10:35:45	10:38:18	1	0	0	0	0	0:02:33	3
7	13:10:27	13:11:11	1	1	1	1	0	0:00:44	0
8	14:13:13	14:20:56	1	1	1	1	2	0:07:43	2
9	7:33:35	7:38:02	1	1	1	1	0	0:04:27	0
10	8:16:44	8:19:09	1	0.5	1	1	0	0:02:25	0.5
11	9:23:44	9:25:04	0	0	0	0	0	0:01:20	4
12	10:25:50	10:29:17	1	1	1	1	0	0:03:27	0
13	11:19:21	11:21:13	1	1	1	1	0	0:01:52	0
14	11:32:01	11:34:00	0	1	1	1	0	0:01:59	1
15	11:41:12	11:43:17	1	1	1	1	0	0:02:05	0
16	12:55:51	12:59:44	1	1	0.5	0	0.5	0:03:53	2
17	13:57:12	13:59:47	1	1	1	1	0	0:02:35	0
18	14:13:32	14:15:18	1	1	1	1	0	0:01:46	0
19	15:37:54	15:40:09	1	1	1	1	0	0:02:15	0
20	15:52:36	15:56:20	1	1	1	1	0	0:03:44	0
21	8:56:33	9:01:08	1	0.5	1	1	0	0:04:35	0.5
22	10:24:34	10:27:16	1	1	1	1	0	0:02:42	0
23	10:49:53	10:54:00	1	1	1	0	0	0:04:07	1
24	11:10:35	11:12:57	1	1	1	1	0	0:02:22	0
25	11:44:10	11:49:30	1	1	1	0	0	0:05:20	1
26	13:46:16	13:48:51	1	1	1	1	0	0:02:35	0
27	14:24:48	14:28:08	1	1	1	1	0	0:03:20	0
28	9:02:00	9:05:16	1	1	1	1	0	0:03:16	0
29	10:59:17	11:01:39	1	1	1	1	0	0:02:22	0
30	11:17:11	11:20:58	1	1	1	1	0	0:03:47	0
31	12:39:49	12:41:11	1	0.5	1	1	0	0:01:22	0.5
32	15:37:56	15:41:37	1	0.5	0	0	0	0:03:41	2.5
33	15:51:01	15:53:14	1	1	1	1	0	0:02:13	0
34	15:37:56	15:41:37	1	0.5	0	0	0	0:03:41	2.5
35	15:51:01	15:53:14	1	1	1	1	0	0:02:13	0
36	10:18:43	10:20:08	1	1	1	0	0	0:01:25	1
37	13:06:42	13:10:00	1	1	1	1	0	0:03:18	0

List 2

Tester Number	Start Time	Finish Time	List 2						Time taken	Errors
			Card	\$15 Diesel	4L 15/40 Oil	Cheezels	Mars	Extra Purchase		
1	11:14:54	11:17:25	1	1	0	1	0.5	0	0:02:31	1.5
2	11:27:32	11:30:35	1	0.5	1	1	1	0	0:03:03	0.5
3										
4	14:55:15	14:59:26	1	1	1	1	0.5	0	0:04:11	0.5
5	21:01:52	21:04:04	0	0.5	0.5	0	0	0	0:02:12	4
6	10:38:28	10:41:54	1	0	0	0	0	0	0:03:26	4
7	13:11:19	13:12:32	1	1	1	1	1	0	0:01:13	0
8	14:21:20	14:31:53	1	1	1	1	1	0	0:10:33	0
9	7:38:14	7:44:14	1	1	1	1	0.5	0	0:06:00	0.5
10	8:19:21	8:22:26	1	1	1	1	0.5	0	0:03:05	0.5
11	9:25:13	9:35:09	1	1	1	1	1	0	0:09:56	0
12	10:29:33	10:31:46	1	1	1	0	1	0	0:02:13	1
13	11:21:42	11:24:25	0	1	1	1	0	1	0:02:43	3
14	11:34:52	11:38:14	1	1	1	1	1	0	0:03:22	0
15	11:43:26	11:46:11	1	1	0	1	1	0	0:02:45	1
16										
17	14:00:12	14:06:48	1	1	1	1	1	0	0:06:36	0
18	14:15:27	14:18:40	1	1	1	1	1	0	0:03:13	0
19	15:43:11	15:46:33	1	1	1	1	0.5	0	0:03:22	0.5
20	15:56:32	16:01:19	1	1	1	1	1	0	0:04:47	0
21	9:01:35	9:08:27	1	1	1	1	0.5	0	0:06:52	0.5
22	10:27:29	10:29:50	1	1	1	1	0.5	0	0:02:21	0.5
23	10:54:46	10:59:12	1	1	1	1	0.5	0	0:04:26	0.5
24	11:13:05	11:15:35	1	1	1	1	1	0	0:02:30	0
25										
26	13:49:02	13:52:31	1	1	1	1	1	0	0:03:29	0
27	14:28:26	14:32:20	1	1	1	1	0.5	0	0:03:54	0.5
28	9:05:28	9:09:39	0	1	1	1	0.5	0	0:04:11	1.5
29	11:01:47	11:05:59	1	1	1	1	1	0	0:04:12	0
30	11:21:17	11:25:44	1	1	1	1	1	0	0:04:27	0
31	12:41:30	12:45:42	1	1	1	1	1	0	0:04:12	0
32	15:41:57	15:46:07	1	1	0	1	1	0	0:04:10	1
33	15:53:24	15:56:37	1	1	1	1	1	0	0:03:13	0
34	15:41:57	15:46:07	1	1	0	1	1	0	0:04:10	1
35	15:53:24	15:56:37	1	1	1	1	1	0	0:03:13	0
36	10:20:23	10:22:52	1	1	1	1	0.5	0	0:02:29	0.5
37	13:10:21	13:13:28	1	1	1	1	1	0	0:03:07	0

List 3

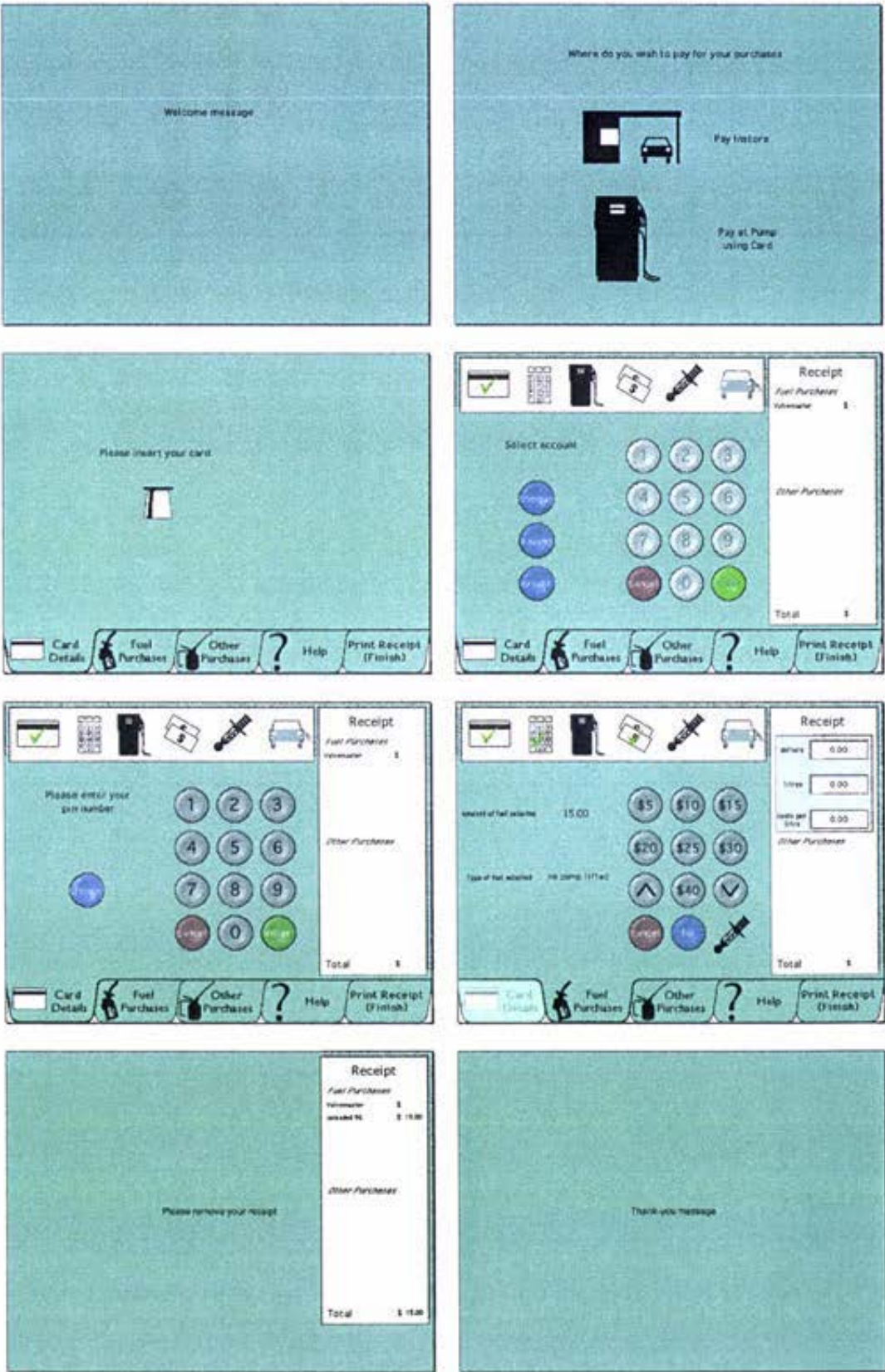
Tester Number	Start Time	Finish Time	List 3							Time Taken	Errors
			Pay Instore	Fill 96	Valve-master	Pebbles	Dairy Milk	Crunch	Extra Purchase		
1	11:17:29	11:18:52	1	1	1	1	1	1	0	0:01:23	0
2	11:30:45	11:32:55	1	0.5	1	1	1	1	0	0:02:10	0.5
3	11:50:14	11:58:05	1	1	1	1	1	1	1	0:07:51	1
4	14:59:34	15:01:05	1	0.5	1	1	1	1	0	0:01:31	0.5
5	21:04:41	21:05:37	1	1	1	1	1	1	0	0:00:56	0
6	10:42:03	10:47:05	1	1	1	1	1	1	0	0:05:02	0
7	13:12:43	13:13:44	1	1	1	1	1	1	0	0:01:01	0
8	14:32:11	14:35:53	1	1	1	1	1	1	0	0:03:42	0
9	7:44:27	7:46:29	1	1	1	1	1	1	0	0:02:02	0
10	8:22:39	8:24:07	1	1	1	1	1	0	0	0:01:28	1
11	9:35:45	9:38:39	1	1	1	1	1	1	0	0:02:54	0
12	10:31:56	10:33:19	1	1	1	1	1	1	0	0:01:23	0
13	11:24:48	11:27:56	0	1	1	1	1	1	0	0:03:08	1
14	11:38:24	11:39:15	1	1	1	1	1	1	0	0:00:51	0
15	11:47:27	11:48:40	0	1	1	1	1	1	0	0:01:13	1
16											
17	14:07:02	14:09:45	1	1	1	1	0	1	0	0:02:43	1
18	14:18:47	14:19:28	1	1	0	0	0	0	0	0:00:41	4
19											
20	16:01:28	16:04:36	1	1	1	1	1	1	1	0:03:08	1
21	9:10:37	9:13:53	1	1	1	1	0.5	1	0	0:03:16	0.5
22	10:30:00	10:31:05	1	1	1	1	1	1	0	0:01:05	0
23	10:59:27	11:01:57	1	1	1	1	1	1	0	0:02:30	0
24	11:15:47	11:17:17	1	1	1	1	1	1	0	0:01:30	0
25											
26	13:52:46	13:57:44	1	1	1	1	1	1	0	0:04:58	0
27	14:32:40	14:34:11	1	1	1	1	1	1	0	0:01:31	0
28	9:10:10	9:13:41	1	1	1	1	1	1	0	0:03:31	0
29	11:06:06	11:07:29	1	1	1	1	1	1	0	0:01:23	0
30	11:25:57	11:27:59	1	1	1	1	1	1	0	0:02:02	0
31	12:45:57	12:47:07	1	1	1	1	1	1	0	0:01:10	0
32	15:46:18	15:49:59	1	1	1	1	1	1	0	0:03:41	0
33	15:56:44	15:57:57	1	1	1	1	1	1	0	0:01:13	0
34	15:46:18	15:49:59	1	1	1	1	1	1	0	0:03:41	0
35	15:56:44	15:57:57	1	1	1	1	1	1	0	0:01:13	0
36	10:23:02	10:24:59	1	1	1	1	1	1	0	0:01:57	0
37	13:13:44	13:16:12	1	1	1	1	1	1	0	0:02:28	0

List 4

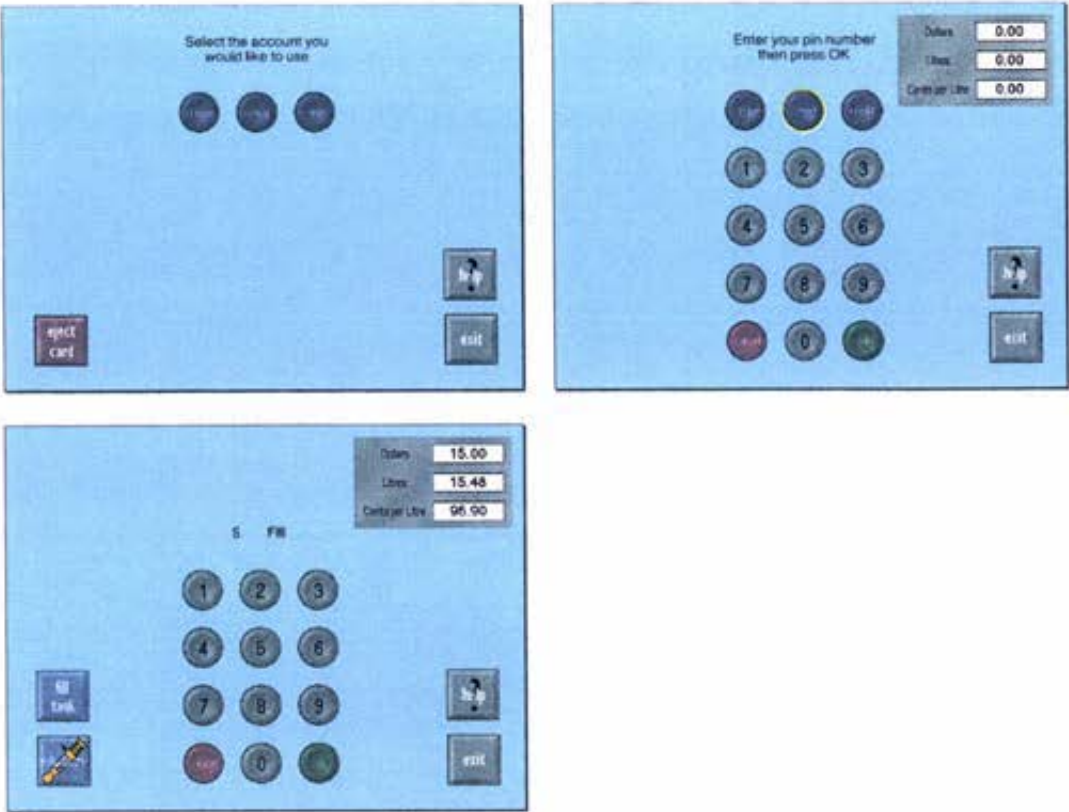
Tester Number	Start Time	Finish Time	List 4					Time Taken	Errors
			Card	\$20 91	Super Car Wash	L&P	Extra Purchase		
1	11:18:54	11:20:34	1	1	1	1	0	0:01:40	0
2	11:33:14	11:35:39	1	1	1	1	0	0:02:25	0
3	11:59:44	12:02:56	1	1	1	1	0	0:03:12	0
4	15:01:17	15:03:01	1	1	1	1	0	0:01:44	0
5	21:05:53	21:07:18	1	1	1	1	0	0:01:25	0
6	10:47:18	10:49:39	1	1	1	1	0	0:02:21	0
7	13:13:52	13:15:03	1	0.5	1	1	0	0:01:11	0.5
8	14:36:16	14:38:31	1	1	1	1	0	0:02:15	0
9	7:46:37	7:48:06	1	1	1	1	0	0:01:29	0
10	8:24:18	8:25:43	1	1	0.5	1	1	0:01:25	1.5
11	9:38:51	9:40:38	1	1	1	1	0	0:01:47	0
12	10:33:32	10:35:16	1	1	1	1	0	0:01:44	0
13	11:28:09	11:29:41	1	1	1	1	0	0:01:32	0
14	11:39:23	11:40:27	1	1	1	1	0	0:01:04	0
15	11:48:49	11:49:51	1	1	1	1	0	0:01:02	0
16									
17	14:09:54	14:12:20	1	1	1	1	0	0:02:26	0
18	14:19:35	14:21:21	1	1	1	1	0	0:01:46	0
19	15:46:41	15:48:23	1	1	1	1	0	0:01:42	0
20	16:04:45	16:07:06	1	1	1	1	0	0:02:21	0
21	9:14:56	9:17:35	1	1	1	1	0	0:02:39	0
22	10:31:17	10:34:15	1	1	1	1	0	0:02:58	0
23	11:02:10	11:03:56	1	1	1	1	0	0:01:46	0
24	11:17:23	11:18:50	1	1	1	1	0	0:01:27	0
25									
26	13:57:54	13:59:26	1	1	1	1	0	0:01:32	0
27	14:34:59	14:37:17	1	1	1	1	0	0:02:18	0
28	9:13:51	9:15:56	1	1	1	1	0	0:02:05	0
29	11:07:37	11:09:01	1	1	1	1	0	0:01:24	0
30	11:28:31	11:30:16	1	1	1	1	0	0:01:45	0
31	12:47:49	12:49:14	1	1	1	1	0	0:01:25	0
32									
33	15:58:10	16:00:09	1	1	1	1	0	0:01:59	0
34									
35	15:58:10	16:00:09	1	1	1	1	0	0:01:59	0
36	10:25:06	10:26:15	1	1	1	1	0	0:01:09	0
37	13:16:28	13:18:43	1	1	1	1	0	0:02:15	0

Appendix vi - Graphical User Interface

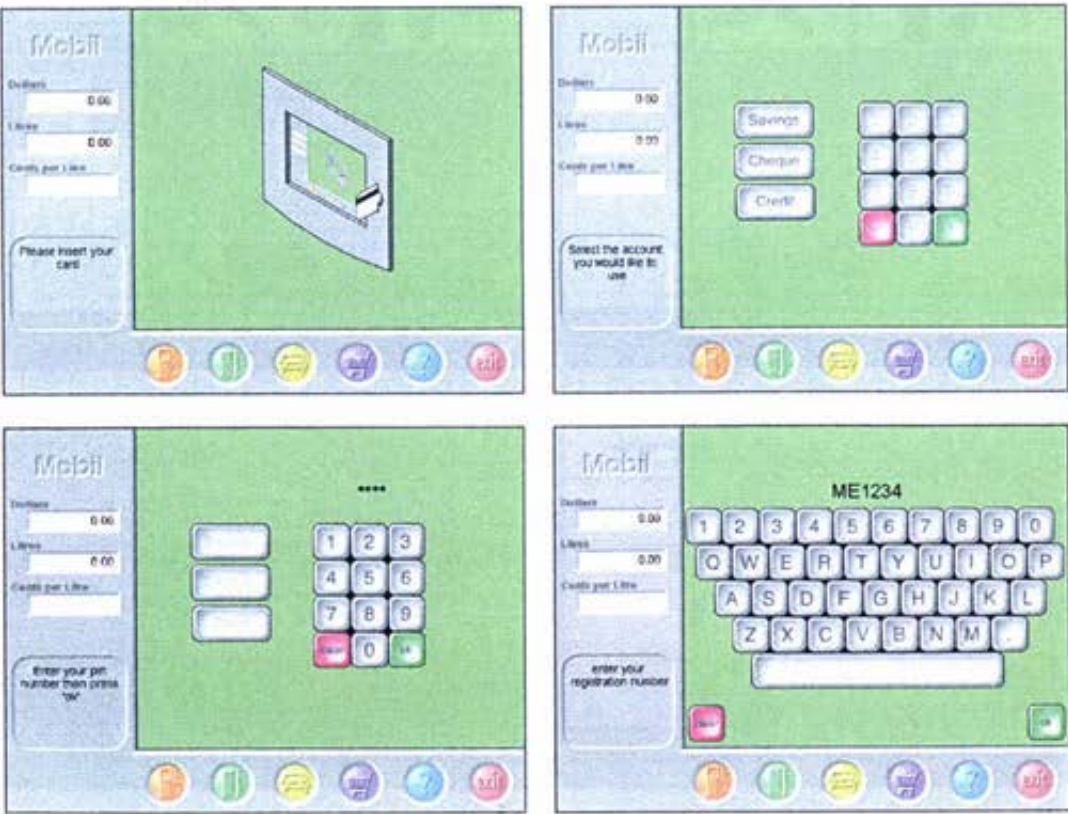
Screen Snapshots – 3/9/97

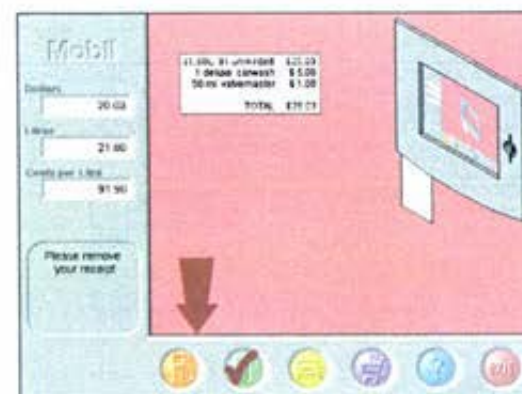
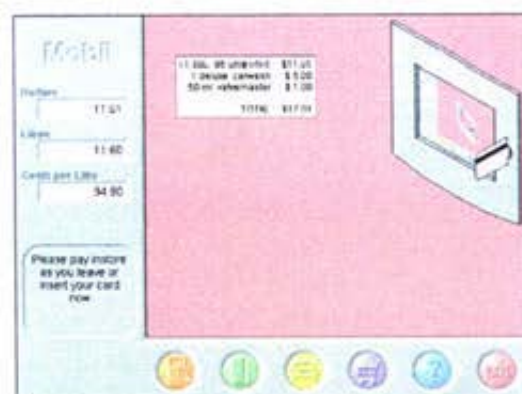
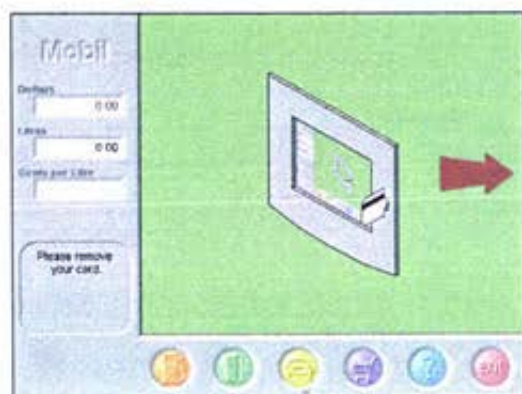


Screen Snapshots – 24/9/97

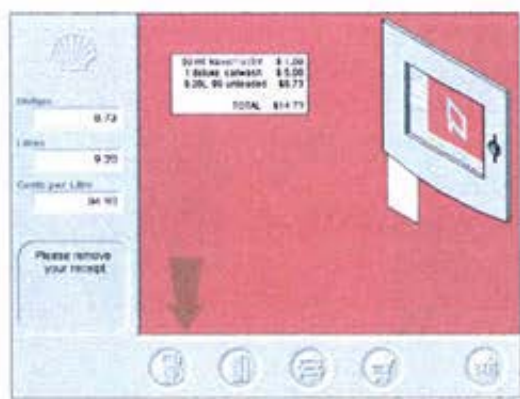
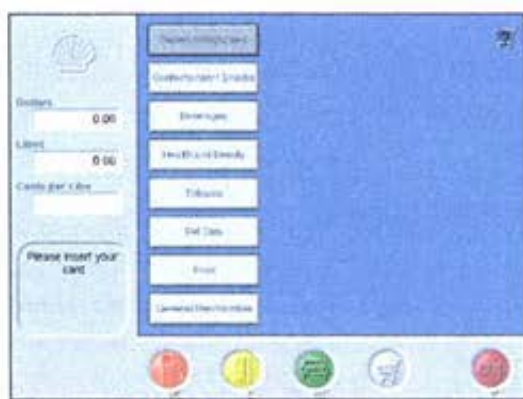
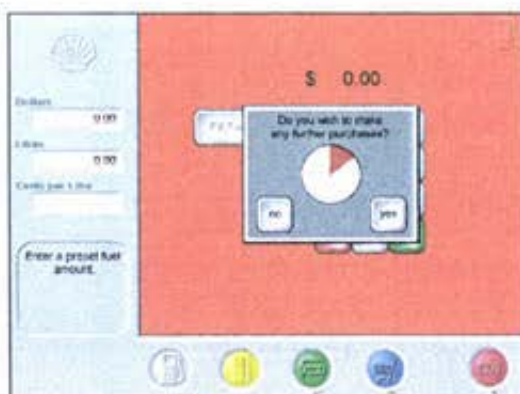


Screen Snapshots – 24/2/98

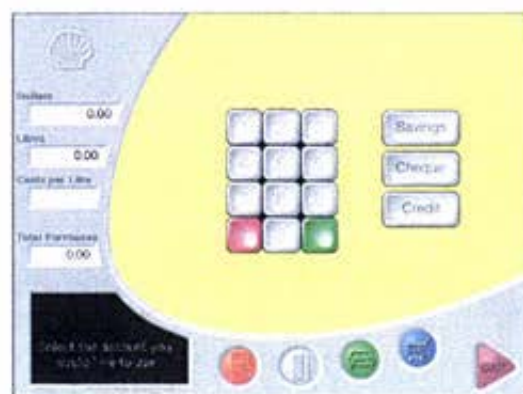
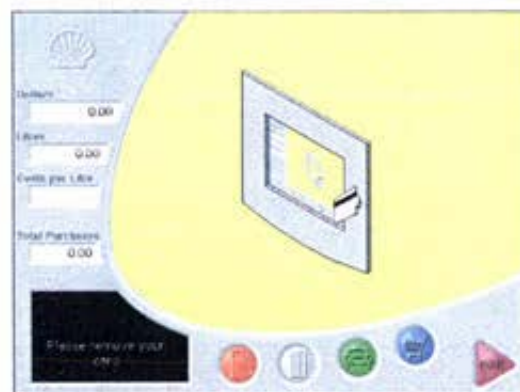
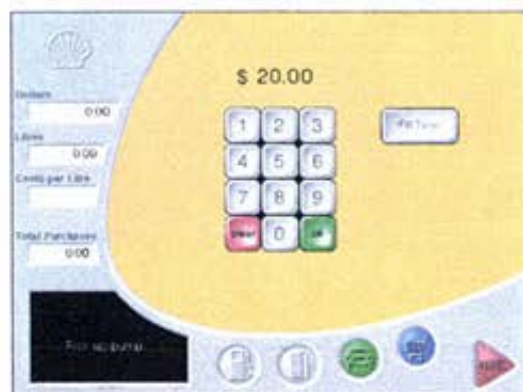


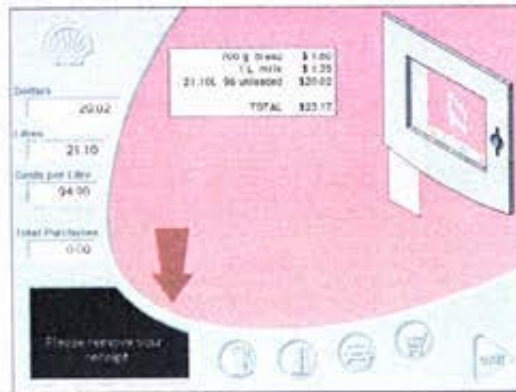


Screen Snapshots – 11/3/98

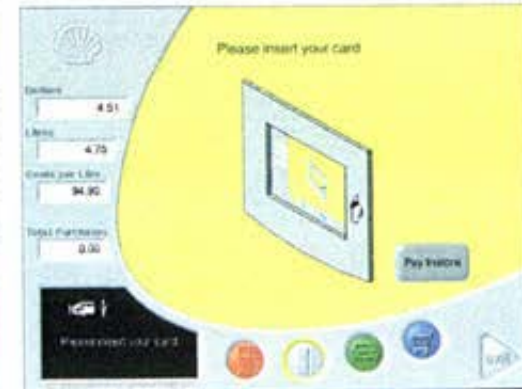
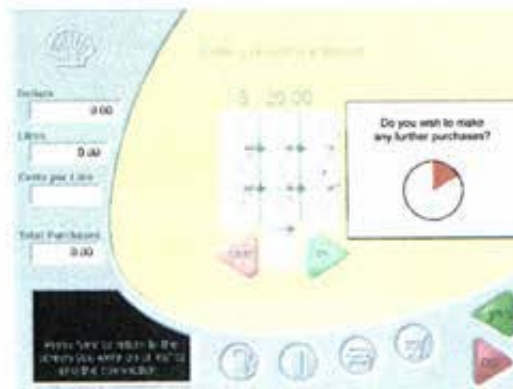


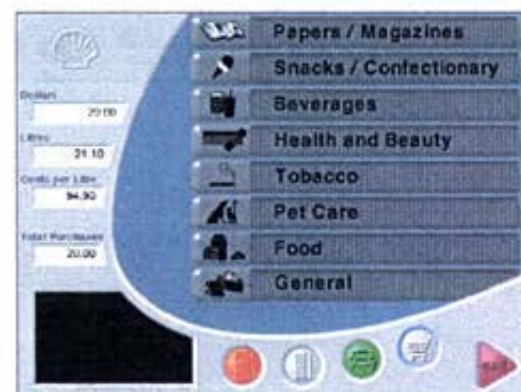
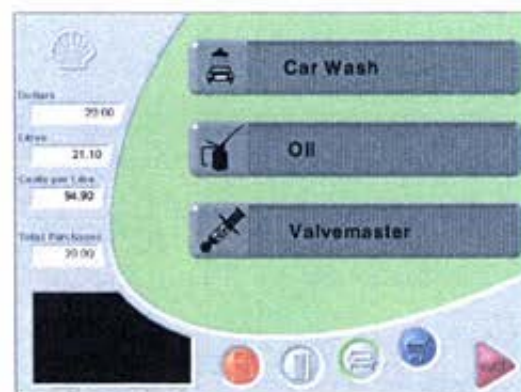
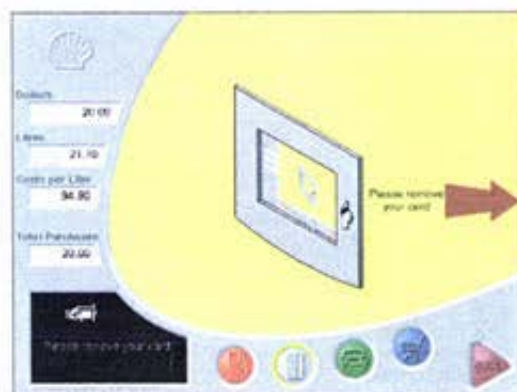
Screen Snapshots – 23/3/98



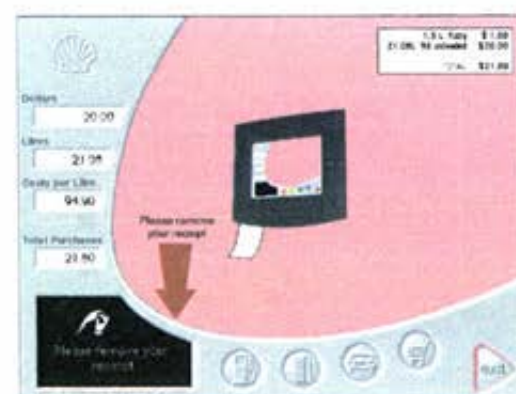
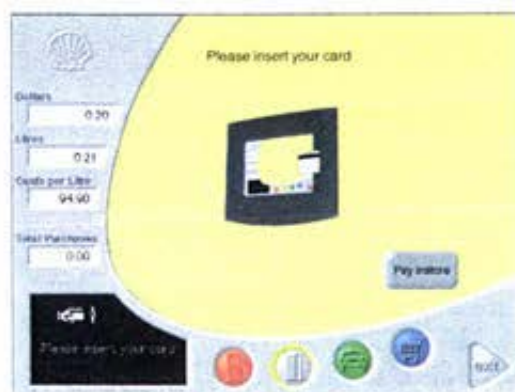


Screen Snapshots – 6/4/98

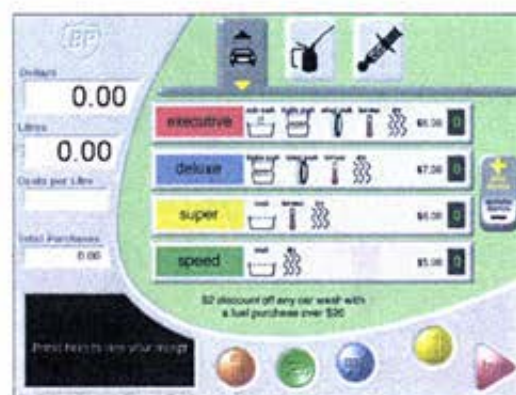
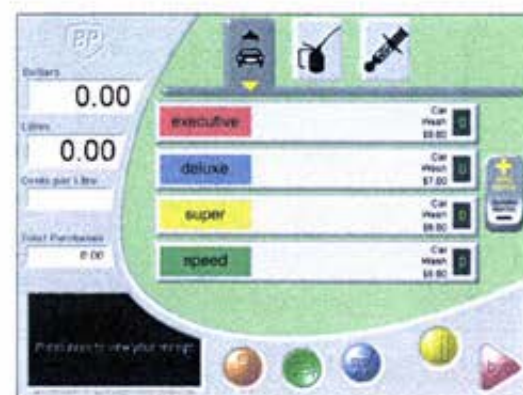




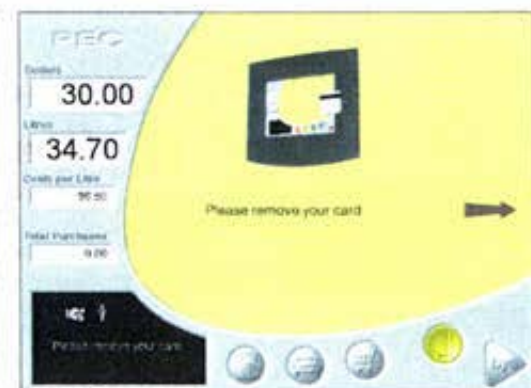
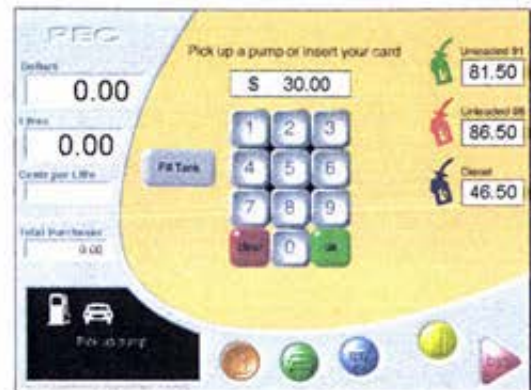
Screen Snapshots – 14/6/98

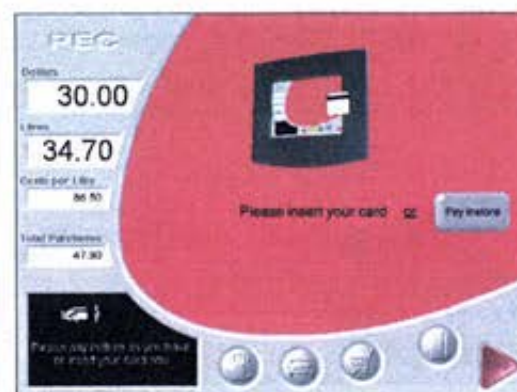
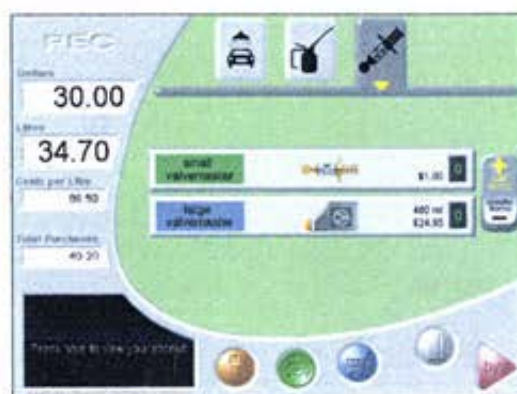


Other Purchases - 22/5/98 - 19/6/98



Screen Snapshots – 30/6/98







Screen Snapshots – 10/8/98

