The Application
of the Product Development Process
in the Development of Architectural Products

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The Application of the Product Development Process in the Development of Architectural Products

Abstract

Historically, methodologies in architecture and product development have differed with one based in art, the other in industry but their similarities are bringing them together. This research compares the Product Design, Product Development Process and Architectural Design Methodologies, showing the differences between them and how they are developing to common structures. Architectural design in the 1990s is presented as a multi-disciplinary solution for complex building systems, including purpose built products, and examples of European architectural firms who develop products with manufacturers are presented.

Opportunity exists in New Zealand for product development to be utilised in architectural projects. A project investigated the design, development and production of an architectural product in New Zealand, where a combined Product Design and Development Process was integrated with Architectural Design. This was the design and development of a trolley system for the new Palmerston North Library.

The Product Development and Architectural Processes need to be interrelated for a total design approach in development projects to produce and market products. This requires a greater emphasis on the inclusion of end user involvement in the building up of ideas and evaluation procedures throughout the development process. Also needed is a better understanding of manufacturing processes and product development. This integration of the Product Development Process including final marketing with architectural design can be achieved by forming multi-disciplinary teams or networking with other professionals for example manufacturing engineers and consumer researchers. This integration should produce marketable products. The research concludes that Product Development is an effective method for designing architectural products in New Zealand for the local market and for export.

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Introduction

In a society changing continually with technology as an active ingredient, environments are required to be flexible and interactive. The main drive for this has been the transfer from an industrial age through an electronic revolution to what is termed the 'Second Machine Age' (also known as the Information Age). Just as the robot has revolutionised the processes of production, the computer has altered the way most of the western world operates. The First Machine Age meant struggling to reconcile the art and craft of architecture with the new machinery of industrial production. Most early Modernists were concerned mainly with the new style rather than understanding industrialised production methods.

The Second Machine Age can be associated with the introduction of the television, but more so of the computer. The microprocessor has allowed modern industry to provide benefits for the masses especially in the areas of consumer goods, automobiles, and communications, by flexible mass-production lines. Buildings of the Second Machine Age are complex systems that contain complex subsystems made of many mass produced products such as ducting, electrical, heating and computer controlled lighting systems. These truly 'smart buildings' are technology based and require a multi-disciplinary approach in their creation.

The methodologies of architecture and product development have differed, but despite this, architectural practices often design products for their buildings. Some of the reasons for this include: a complete design service to the client; control of service and design; the unavailability of the required goods; local production quota restrictions; budget; lead times; and monetary gains.

In public and commercial spaces, products such as lighting, furniture, shelving and carpets have substantial budgets and involve a large proportion of the research and development in their production, but are typically designed on a job-by-job basis. In this situation, many practices fail to realise the potential in design for sustainable manufacture, and produce 'one off' designs that ideally should be, or could be mass produced. However, there are several architectural firms that design and produce one-offs for a particular job that then become mainstream products. They achieve this through the use of multi-disciplinary teams, and a structured research and development programme with a manufacturer.

This thesis investigates why and how the Product Development process could be utilised in the development of architectural products. Chapter One studies the historical development of product development and architectural and product design.

Product Development is part of a company's business strategy to launch new and improved products onto the market. The Product Development Process is a multi-disciplined co-ordinated project that is undertaken to meet the company's strategic goals including marketing, business and technology plans

Product Design forms part of this project and consists of the product design specification (or 'product concept') development through to the testing of the final prototype. Professionals, namely product and industrial designers, model-makers, technologists and engineers are closely involved in the total project and consider the consumer as well as the manufacturing requirements in the Design Process.

Architectural Product Design encompasses the design and development of products for architectural environments. These products may be developments in building materials and finishes, or any item in an interior. In this context architectural products offer a large area of potential for product and industrial designers to exploit, using a structured development process. This is especially the case in New Zealand where: overseas lead times can be extremely long; quotas[1] exist for public and government interiors; architects specify overseas products because they regard New Zealand made products substandard. This country has the primary resources and skill base to produce value added architectural products.

There is a need to compare Product Design and Architectural Methods to see if they can be integrated for use in an architectural context for a total design approach. Cooper(1983) reviewed the uptake of the Product Development Process and its success within the manufacturing sector, but within architecture there has been little research to date. Abel(1986) in *Ditching the dinosaur sanctuary* suggested architects become more aware of industrial design practices and manufacturing processes.

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[1] A quota of 70% New Zealand content exists for publicly funded projects. This is to limit import of product and give local firms an opportunity.

Within the Architectural industry there are very few examples of firms who have Research and Development programmes in place as part of their strategic goals. The architectural practices of Norman Foster and Associates, and Richard Rogers + Partners are the major exceptions. They employ industrial and product designers, other specialists when required, and work closely with engineers and manufacturers to develop products. Examples of their product work is presented and discussed in Chapter Two.

The design and development of a library trolley system was selected as a project to validate Architectural projects using product development methods in practice within New Zealand. This project was undertaken by the researcher, in conjunction with, Athfield Architects of Wellington, for the Palmerston North City Council library, and was completed in May 1996.

The objectives for this thesis were:

• To compare Architectural, Product Design and Product Development Methodologies.

• To investigate the historical development and compare the differences between the Product Development Process and Architectural Design Methodologies.

• To study architectural firms that have integrated development methods within their Architectural methodology and design philosophy.

• To undertake an integrated method of product development for an architectural product within an architectural environment in New Zealand by:

-Recording the actual process used in the development process and;

-Recording the decision making process and ascertain how it affects the development process.

• To investigate and confirm that a systematic and structured process can be overlaid on the architectural design process with a user focus.

It must be noted that the aim was not to come up with a new methodology: but to prove that an understanding of the processes and their manipulation, can lead to more efficient building projects, as well as successful commercial products. No attempt is made in this paper to define "good design" as the work presented is concerned with the theory of navigating towards a final product rather than with the merit of that product, although it should be stated that an efficient process should lead to a better end product. The mere fact that the firms presented in Chapter Two have produced key buildings in Europe and have won countless awards for their work, perhaps is an indication that their process and philosophies are on the road to providing society with more efficient and customer orientated environments and the building industry with a progressive project method.

Chapter One

The Development of Architectural Product Design and Product Development Processes

This chapter introduces an overview of the historical development of design methods as a discipline. The central issues in this research focused on design in architecture, engineering, and product development. Design management is also broadly discussed.

How to Design for a Changing World

Design research literature began seriously in the late nineteen fifties and sixties as designers and educationalists started to inquire more into the process of design itself rather, than the end product. Design methods theory draws from many diverse schools of thought such as: architecture, engineering, mathematics, operations research, philosophy, management science, behaviorism, psychology, sociology, and personal beliefs.

Jones (1970) outlined that the appearance in the sixties of the 'design methods movement' sought to systemize the current subjective methods into a more objective and open design process. It was a reaction to the craft-based approach to design, namely the trial-and-error and the evolution methods, then the design-by-drawing method which allowed for the division of labour in the production of products. This design-by-drawing method was viewed by design theorists to be too simple for the growing complexity of the man-made world. Society had the right to expect designer's to be "accountable" and responsible for the process they used because of the wide ranging effects of their end products in a technological society (Lawson, 1991). Therefore the subjective process became objective and systematic as designing become more difficult in a rapidly changing technological world. The number of new materials, variation in manufacturing methods, performance of the finished article, high costs of design errors, and product liability have all combined to increase the complexity of the designer's role.

Grant (1986, p.390), suggested another ingredient for the move to systematic methods was the long list of scientific breakthroughs such as DNA and nuclear fission occurring at the time. These changed the whole situation in which we lived, and "the fashion in modes of thought". Grant also cited the emerging use of the computer for manipulation of quantifiable data as a factor in the systematic movement.

The common aim of the methods at this time was that all the methods are attempts to make public the hitherto private thinking of designers; to externalize the design process and to provide a more manageable process, particularly at the systems level. An advantage of this is that other people, such as users, can understand and participate by contributing "information and insights that are outside the designer's knowledge and experience" (Jones, 1970, p.45).

Design and Design Methodology Definitions

Cross (1984), broadly described Design Methodology as the principles, practices and procedures of design. The definition of designing varies among writers, depending on their background, but a common thread is the "creation of something new that did not exist previously" (Roy 1972, p.5). Luckman (1984, p.84) insisted that some creativity or originality must enter into the process for it to be called design. If the alternative solutions can be written down by strict calculation, then the process that has taken place is not design. Roy (1972), also suggested the word design means "purpose or plan" as does the Oxford English Dictionary.

Perhaps the most apt definition was delivered by Jones (1970) after studying a variety of definitions by Alexander (1963), Archer (1965), and others in the field between 1962 and 1968, he concluded that the effect of designing is to "initiate change in man-made things" (Jones, 1970, p.4). Thus it includes not only the actions of design professionals (architects, engineers, industrial designer) but also town planners, legislators, applied researchers, managers, politicians, and pressure groups in their attempts to change cities, laws, public services, buildings, opinions, products, markets, and so on.

Cross concluded that design methodology as a discipline includes the study of how designers work and think; the establishment of an appropriate structure for the design process; the development and application of new design methods, techniques, and procedures; and reflection of the nature and extent of design knowledge and its application to design problems (Cross, 1984, p.vii).

Growth, Development and Application of Design Methods

This section outlines the development of design methods from the early 1960s of the systematic and rational (1st. generation) procedures to designer behaviour, then the heuristic movement also termed holistic design or second generation. The reflective practitioner era which consisted of a reflection-in-action approach is investigated, and finally a summery of other design methods such as systems approaches, statistical models and computer-aided design are discussed.

Systematic Methods

Cross (1984) outlined in the introduction to *Developments in Design Methodology*, that in the early 1960s, theorists were primarily concerned with the development of systematic procedures: in which attempts were made to restructure the design process based on the new methods of problem solving, management, and operational research, which had been developed in World War II and the 1950s. Design in these 'first generation' methods as they were also termed, was viewed as a rational process. Of this era the best known examples according to Broadbent (1979) are Asimow (1962), Jones (1963), Archer (1963/4) and Alexander[1](1964). Figure 1 shows an Iconic Model of a design process as presented in Rowe (1987) - proposed by Mesarovic 1964 and Watts 1966, that is congruent with the Asimow model (1962).

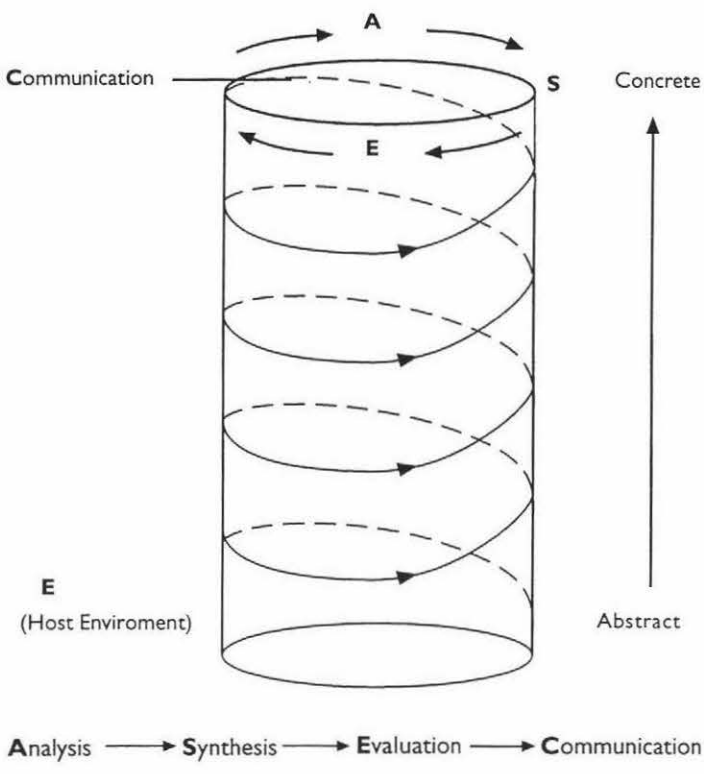

figure 1. An iconic model of a design process.

The horizontal sequence is represented as a cycle that begins with analysis, proceeds through synthesis and evaluation to communication. Asimow viewed the cycle as an iterative cycle between and within the various phases of activity. Analysis is defined as the ordering and structuring of a problem and involves: the exploration of relationships; forming patterns in the information available; and the classification of objectives. Synthesis is the generating of solutions; an attempt to create a response to the problem.

[1] Alexander's seminal book *Notes on the Synthesis of Form* appeared in 1964.

Evaluation involves critical analysis of suggested solutions against the objective formulated in the analysis phase Lawson (1991). The disbursement of information so that tasks can be undertaken is the communication component.

Archer's (1963/64) design process model is schematically represented in figure 2 as shown in Rowe. Three interrelated realms for the process: external representation; process of activities; and the problem solver, along with more pronounced feedback loops distinguish it from previous models, although it is from the behavioural realm (Rowe 1987).

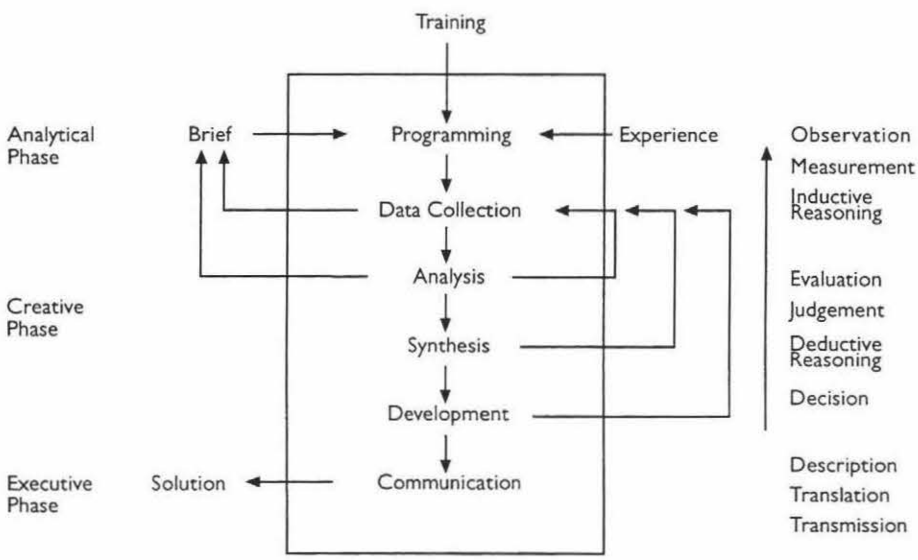

figure **2** Archer's design process (1963)

Designer Behaviour

It was then realized that design problems could not be totally solved through systematization and therefore attention turned to the ill-structured nature of design problems, this occurred from the period 1966-73. This period tried to understand and describe the complexity of problems, and centered around the investigation of designer behaviour through controlled laboratory experiments to open-ended interviews. The aim was to develop a greater understanding of how designers resolve complex problems. Simon (1969) introduced problem solving theories that provided a framework for this type of study within the paradigm of technical rationality.

Heath (1984) pointed out this was an active period for design research in terms of conferences and publications. The Birmingham symposium, subsequently published as The Design Method (Gregory, 1966) occurred in 1965. in 1968 the Portsmouth conference in England addressed design methods in Architecture (Broadbent and Ward, 1969), and also the American Design Methods Group held its first international conference at Cambridge, Massachusetts (Moore, 1970).

Christopher Jones produced a critical review of all research activity up to 1970 in his *Design Methods - Seeds of Human Futures* (Jones, 1970), and Broadbent (1973) produced a similar review for architecture in his *Design in Architecture*. Markus (1969) and Maver (1970) developed maps of designing based on the RIBA[2] plan of work of the design process which consisted of four phases: assimilation; general study; development; communication: with feed-back loops between the first three elements. In the model shown in figure 3 where they insisted that a complete representation of design requires decision sequence as well as a design process. They suggested the need to progress through the decision sequence of analysis, synthesis, appraisal, and decision at increasing levels of the detail in the design process.

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[2] R.I.B.A - Royal Institute of British Architects.

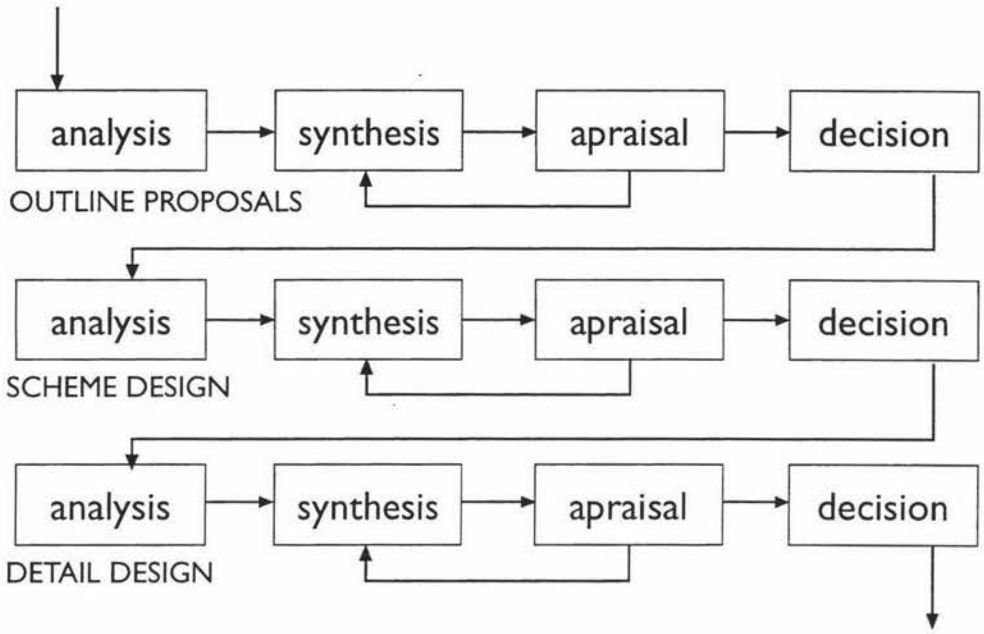

figure **3.** The Markus/Maver design process incorporating decision sequence.

From 1972 onwards a more fundamental and philosophical approach emerged which drew upon the knowledge and lessons learned in the first decade of design methodology.

Heuristic Methods

In 1972 Rittel, Protzen, and Grant presented what they considered a new direction or "second generation" in design methods. The intention was to extend the scope of method to ill-constrained or what Rittel coined "wicked" problems. Second-generation methods are heuristic[3] search processes, which make use of hypotheses and the information that the testing of each successive hypothesis generates to limit the subsequent field of search (Heath, 1984, p.128). Rittel (1972) and Broadbent (1979) observed that successful design methodologies must be more open,

[3] Perkins defines a heuristic as "a rule of thumb that often helps in solving a certain class of problems" (Perkins 1981, p 192).

flexible, and iterative than the rigid first generation systematic methods allow.

Rittel's methods include argument and debate, since they admit that part of the problem in design lies in deciding what ought to be done. Other characteristics which distinguish them from those of the first generation are: augmented problem space, where designs are subsets or consequences of broader issues; "symmetry of ignorance" where both sides have essential knowledge, a logical argument for using participatory methods; transparency of decision making and arguments used, which equates with Jones (1970) "glass box" methods; objectification in that the process is recorded; delegation of judgment to the designer be understood and agreed; and the "conspiracy model, of planning" where designers and users bring about first agreement and then action. All these characteristics evoke an interactive rather than a reactive model of the design process (Heath, 1984).

How Designers Think (Lawson, 1991) presented the empirical and protocol experiments of Drake (1978) and Lawson (1972, 1979) and later Rowe (1987) that explored the subtleties about design as it is actually practiced. These protocols show how designers explored the problem through a series of attempts to create solutions. As Rowe (1987) reported "...several distinct lines of reasoning can be identified, often involving the *a priori* use of an organizing principle or model to direct the decision making process". The results showed also that there is a very close or inseparable relation between analysis and synthesis as opposed to earlier step by step methods such as the RIBA Plan of Work (1966). (Lawson 1991, p.33) states Akin (1986) found that "designers were constantly both generating new goals and redefining constraints".

Reflective Practitioner

Dorst and Dijkhuis (1995) outlined how Schön (1983) reacted to the rational problem solving approach which had been the dominant doctrine in prescriptive and descriptive design methodologies since their conception. Schön proposed "a new theory of design" by describing design as a process of "reflection-in-action" which addresses some of the shortcomings he perceived in mainstream methodology, namely in the training of practitioners. This includes generalities about design problems and design processes without a concrete linkage between the two. He stated a core skill of designers lies in determining how every problem should be tackled which has always been left to the "professional knowledge" of experienced designers. Schön refers to this as "the artistry" of design practice. Thus these problems cannot be described in the prevalent analytical approaches, and their solving cannot be taught.

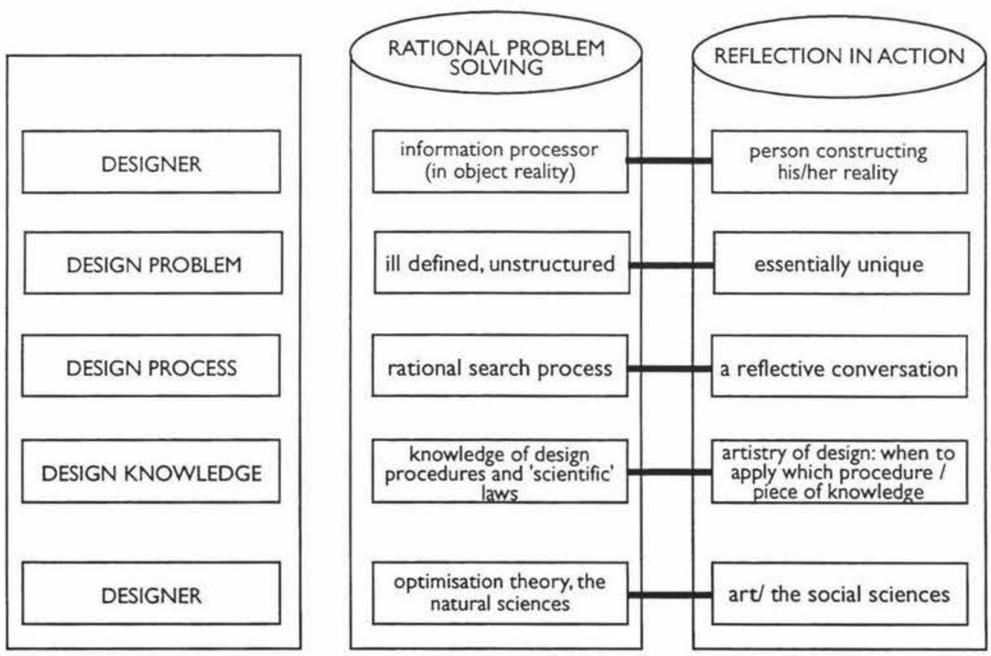

figure **4.** Schön's reflection-in-action summary of paradigms.

Schön's alternative was based on human perception and thought processes where he viewed design as a "reflective conversation with the situation". Problems are actively "framed" by designers, who make "moves", and evaluate these, improving the perceived current situation. Dorst and Dijkhuis (1995) presented a summary of the rational problem solving, and Schön's reflection-in-action paradigms, as can be seen in figure 4 .

Other Design Methods

It can be seen from the literature presented that the "science" of design is primarily based on models derived from theories from the logical-empirical sciences where methodologies are based on problem solving, analysis, synthesis, and evaluation, and models viewed as a mathematical problem that can be solved by prescribed logical steps. Other approaches or models in the areas of "design science" worth mentioning are: systems approaches to urban planning, design-related issues in man-environment studies relying on statistical models based around behavioural science. Computer-aided design (CAD) research responds to models derived from mathematics, logic, language theory and cognitive science. The extension of these, particularly language theory and cognitive science is artificial intelligence. Which enters the realms of expert systems, rule based systems, prototypes and machine learning. (Snodgrass and Coyne,1992).

Snodgrass and Coyne (1992) presented the case that "models are metaphors." Therefore the "semantic" and "disclosive" functions are not founded on their logical structures but convey their meaning via metaphors by way of a hermeneutical[4] understanding. By contrast to scientific models, models based on hermeneutical understanding are capable of providing "felicitous translations of designing as they are

[4] The science of interpretation - including the paradox described by Hirsch (1967, p.259) as "that we cannot perceive the meaning of a part until we have grasped the meaning of a whole" and vice versa.

directly experienced by designers" Snodgrass and Coyne (1992 p.56). Hermeneutical understanding in architecture, "requires intelligibility on the part of the overall organisation and composition of the work and on the part of its surfaces, framing devices, material, and decoration." Rowe (1987, p.195).

Cross (1984, p.ix) concluded "that the movement has progressed through four stages: prescription of an ideal design process; description of the intrinsic nature of design problems, observation of the reality of design activity and reflection on the fundamental concepts of design". In summary, Systematic or first generation methods leaned towards a industrial design orientation whereas heuristic or second generation methods tried to address the complex issues of town planning and architecture. There is a void between theory and practice with many problems relating to the use of systematic methods and reactions from other theorists, designers, and end users. The key factors for professionals not taking on board the methods include: the methods are hard to use and absorb into practice; the knowledge required is too specific; and terminology used differs from theorist to theorist. It should be mentioned here that computers are still only used as tools to aid drawing and documentation although research is progressing in the area of artificial intelligence. The study of practitioners, as well as method, is advocated by many to understand and aid designers, rather than straight jacketing them with methods they do not use.

It can be seen from the review that the theory of processes cross over from one discipline to another and causes some confusion with the terminology used. Although the processes seem abstract and therefore quite generic, the professionals who work in each field have different specialist skills and knowledge to carry out their respective jobs such as: engineers designing bridges or a plastic injection tool; architects designing buildings and/or houses; and an industrial designer designing furniture or mobile phones. The specific processes for different disciplines including:

The RIBA Plan of Work (1966); the British Standard 7000 - a guide to managing product design (1989); and Cooper's Product Development Process (1983), are presented and compared in the following section. The processes have been chosen for acceptance into their aligning professions.

Architectural plan of work

Taking the model *Plan of Work* published by the Royal Institute of British Architects (1966) as a basis, the normative process that architects follow in the program for a building is shown in figure 5.

Stage A - Inception
1. set up client organisation for briefing
2. consider requirements
3. appoint architect

Stage B- Feasibility
1. carry out study of user requirements
2. carry out study of site conditions
3. examine planning, design and cost feasibility

Stage C- Outline Proposals
1. develop brief further
2. complete study of user requirements
3. carry out study of technical problems
4. carry out study of planning, design and cost problems

Stage D - Scheme Design
1. finalise brief
2. full design of project by architect
3. preliminary design by engineer
4. prepare cost plan
5. prepare full explanatory report
6. submit proposal for all approvals

Stage E - Detail Design
1. complete designs for every part and component of building
2. complete cost checking of designs

Stage F - Production Information
1. prepare final production drawings
2. prepare schedules
3. prepare specifications

Stage G - Bills of Quantities
1. prepare bills of quantities
2. prepare tender documents

Stage H - Tender Action
1. dispatch tender documents
2. examine tenders and select tenderers
3. let contracts
4. notify unsuccessful tenderers

Stage I - Project planning
1. arrange effective communications system
2. agree project programme

Stage J - Operations on site
1. provide design and construction information
2. implement construction programme
3. install and effect budgetary control
4. install and effect quality control

Stage K - Completion
1. inspect completed construction
2. specify rectification of defects
3. make good defects
4. complete contracts and settle accounts
5. relinquish possession to owner

Stage L - Feedback
1. analyse job records
2. inspect completed building
3. study building in use

figure **5.** Royal Institute of British Architects Plan of Work (1966).

Product Design

Product design is a creative and complex process which involves the integration of specialist skills and knowledge bases, including such as the skill base of industrial designers and engineers. Slappendel (1996) stated that Flurscheim when explaining that the industrial design specialism generally embraces aesthetics, ergonomics, graphic techniques and provides tools that can assist in the specification of what is needed by the market, and in the design of the human/machine interface. Slappendel adds that Moody (1984) stated that with the integration of the Industrial Design techniques, some of the omissions of engineering design can be rectified. Efficient product design and manufacture requires the integration of components so as to meet the highest possible performance specification for the whole. In reference to conceptual engineering design, methodological approaches look at the enhancement of the creative process with the aim to active intervention in the unfolding of the process as opposed to environmental approaches which establish an environment in which creativity is more likely to occur.

The British Standard 7000 outlines the management of product design. The flow diagram in figure 6 is the idealized product evolution as presented in BS 7000.

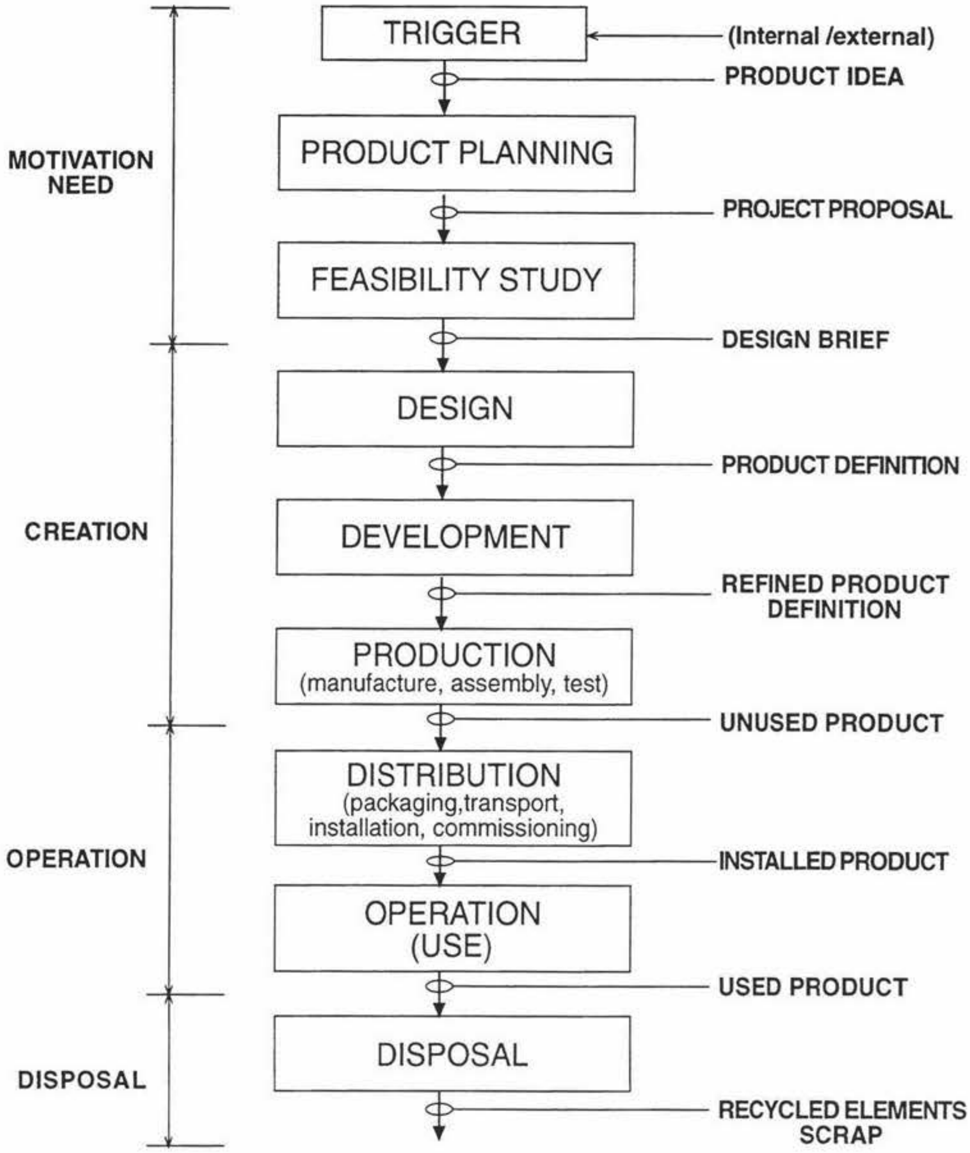

figure **6.** Idealized Product Evolution - British Standard 7000.

Management of The Design Process

This area has gained recognition and impetus in the last twenty years, as a way of controlling the process to meet a company's strategic objectives and investment returns. Another important area of management is the culture and environment of companies where products are developed.
The British Standards 7000 (1989) and BS5750 are an indication of the acceptance of methods and procedures being integrated into practice. The 7000 standard suggests a matrix management for multi-disciplinary groups that develop products and offers a typical evolution of a products

development as figure 6 shows. The BS5750 standard, originally written in the 1970s for manufacturing companies, is now promoted as a Quality Assurance standard for service industries. With the certification, which is similar to the International Standards Organisation (ISO) 9000 series predominantly used in New Zealand, companies can confirm that they offer a professional service.

The Product Development Process

The Product Development Process is essentially the conception, development, testing, and commercializing of products. The use of a development process that is systematic allows for a product to be developed completely, ensuring all details are not overlooked. Therefore the aim of the Product Development Process "is to co-ordinate development activities, optimize the product's market potential, and reduce the inherent risk of developing new products" Kerr (1995, p.1).

Product Development research appeared in the late 1960s when Booz-Allen and Hamilton (1968) investigated what actually occurred in the development of new products and how it was managed. Findings showed that there was a process, although quite primitive, that gave management a 'game plan' that assisted in the development and planning of new products.

A characteristic flow diagram for the development of consumer goods, as presented by Cooper (1984) is shown in figure 7.

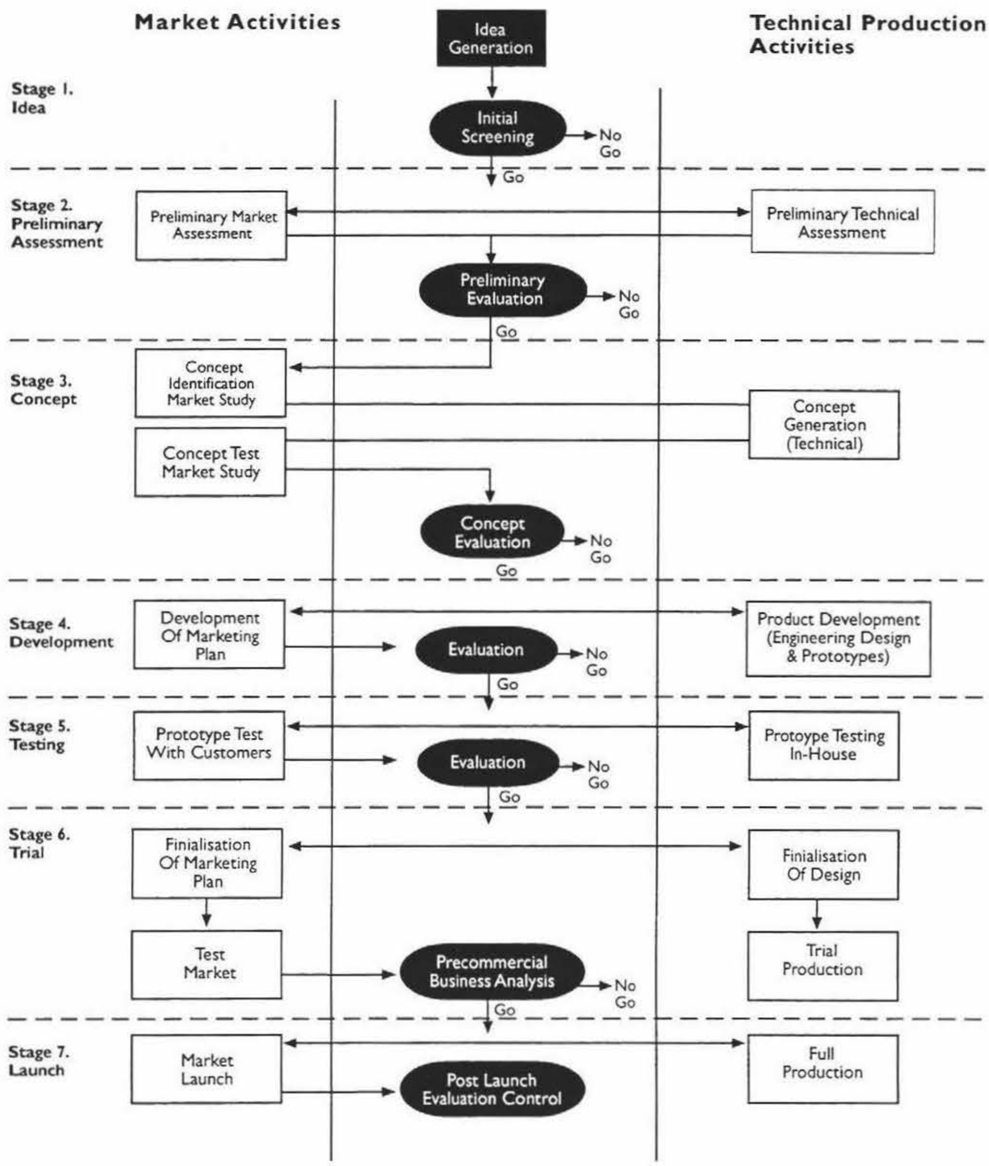

figure **7.** Cooper's (1983) seven stage new product process.

Comparison of Architectural Design, Product Design and the Product Development Processes

Having shown that architecture and product development and product design share common goals and methods on a abstract and theory level, the processes are shown in table I to compare their differences and similarities.

The emphasis of each process can be expressed in the following terms:

The **Product Development Process** has an emphasis on consumer and market research, testing and evaluation especially at the early concept stages. The plan addresses both market and technical activities while the architectural and product design lean more towards a technical orientation. However the product development process includes technical specialists early in the process where the other two bring in specialists at the development stage. All three processes have some form of planning and feasibility stages which also include some form business analysis on a strategic level. The Product Development Process is usually instigated in-house by a manufacturing company and therefore very rarely has a client, consumers in this process are what the architectural industry would term the public or end user.

The **Product Design Process** is similar to product development in terms of the number of stages involved, but product design has less initial idea screening and testing in the market. Like the Architectural Process there is a close relationship with a client. The process places an emphasis on models to develop and communicate ideas with the client. Both the Product Design and Product Development processes have procedures for the evaluation of ideas and concepts. The Product Design Process has a disposal and recycle cycle at the end, while the Architectural and Product Development processes have feedback and post launch evaluation.

The **Architectural Plan** has a loose concept up until the scheme design and as Rowe suggested, it is a valid form of progression through idea formulation (Heuristic methods) and the idea is formulated closely with the client at these early stages. The evaluation of stages seems to be controlled by cost and payment progression. There is some identification with users in stage C - Outline Proposals but no mention of testing procedures with users, and there is no trial period at the end of the production phase. The stages of the Architectural process A and B, can be considered equivalent to Product Planning and Preliminary Assessment stages of the other two processes. Stage C is the Concept Stage, D is the Design, E for development and stages F through to J are the production phase if you were to look at a building as a large product. Table I expresses the equivalent stages for each process.

Table 1. Similarities and differences the Architectural and Product Design, and the Product Development Processes.

Arch. Design	Product Design	P.D.Process	**Similarities**	**Differences**
A **Inception**	**Trigger**	1 **Idea**	Need or motivation initiates project	Consumers used early in PDP to formulate ideas
B **Feasibility**	**Product Planning**	2 **Preliminary Assessment**		
C **Outline Proposals**	**Feasibility** Design Brief		Assessment of cost & user requirements Definition of project aims & constraints	PD does not emphasize consumers as much as PDP.
D **Scheme Design**	**Design**	3 **Concept**	Concept testing & evaluation, assessment of technical issues.	PDP *idea* tested with market. AD brief is lose up until this stage. Emphasis on models to develop concepts in PD
E **Detail Design**	**Development**	4 **Development**	Refined product definition in PD&PDP Major developmental part of all processes	AD finalizes brief
		5 **Testing**	User & technical testing in PD&PDP	AD completing designs & costing
F **Production Information** G **Bills of Quantities** H **Tender Action** I **Project Planning**	**Production** -manufacture, assembly, test	6 **Trial**	Final design specifications. PD&PDP in full production, launching distribution, & marketing of product	PDP trial production & test market, development of marketing plan. PD emphasis on refining production. Because of tender AD starts to work with unknowns
J **Completion**	**Distribution** -packaging, transport, installation, commissioning	7 **Launch**		
K **Feedback**	**Operation** (Use)			
	Disposal			
11 stages	9 stages	7 stages		

In conclusion it can be observed that on a general level the processes presented are similar and in some cases equal, but as they break down into component level they change. Even at component level, different jobs within the same profession process will have different tasks performed in different ways and times, depending on the type of job. This can be attributed to client interaction, time scales, environment, contractors, budget and designer personality. This is not within the scope of this paper, but it must be recognized as a contributing factor in the success of the final product. In short every job is different but, experience and review of previous jobs, and an awareness and understanding of the methodology used and the ability to manipulate them, coupled with genuine control of creativity, will produce satisfying results.

Analysis and Critique

Showing the process development over the decades gives a indication of how ideas about what happens in the design process are wide ranging and varied. The variety of methods to chose from is vast. Theory has not translated into practice as the methodologists would have hoped for due to the problems mentioned earlier. The only transition is the BS7000 which represents legislation of the process, however this has been initiated by management sectors. Technology involvement, and the resulting social concerns of complex systems and sub systems has influenced and initiated the management system within design to accommodate and deal with complex problems.

Communication between disciplines is a key factor in success and methods are now coming back to generic process to allow different disciplines to work together in a flexible and manageable process. This is shown in Jones (1984, p.225) roughness theory which involves letting and including non trained people interacting in the process, and relaxing the constraints early on, thus, 'if we had known then what we know now' therefore creating a learn as you go collaboration before concept-fixing.

This paper does not look at or judge the design quality of buildings or products produced as this area is outside the scope of this research. Although it must be stated that the whole reason for the methods research was to improve the outcome and reduce the chance of failures. Understanding of process leads to continual improvement of the processes and hopefully the end results, and it could be argued better design aesthetically, although no study has been carried out to prove this. Study of understanding method produces good solid design that has method checks in place. Investigation of successful practices at work, where we can gain insight into their methods for success will give an appreciation of the practical application of methods. Discussion will show, by way of examples how the integration of the Product Development Process into architecture improves the total end result. This is the theme of the next section.

Chapter Two

Product Development in Architectural Design

The architectural industry has always been multi-disciplined, but it has been concerned primarily with erecting a building. There are few architects who understand the wider ranging skills available to them to create total environments, such as employing industrial designers who understand manufacturing processes, and consumer researchers who understand public needs and attitudes.

This section presents buildings as complex system environments that include mass produced products to meet the demands in a technological age. Inclusion in architectural design of the Product Development Process for mass-produced products is presented in examples of the practices of Norman Foster and Associates and Richard Rogers + Partners. The theme of the hypothesis for this research is focused primarily on the development process of furniture for architectural environments.

Towards Industrialized Building Methods

Since the nineteenth century, when mechanization began to impact on the building industry, architects have been distanced from the production processes by which parts of buildings are made. The teaching at the Bauhaus School reconciled the early craft orientation methods to an emphasis on Industrial Design to try and align the Art and Craft of architecture with the new machinery of industrial production. (Banham 1960, cited in Abel 1988).

Other philosophical influences included Buckminster Fuller's lightweight, all-purpose geodesic domes, Mies van der Rohe's steel structures and Le Corbusier's "machines for living in". Jean Prouvé was one of the four early architects to take Industrial Design seriously by maximizing the performance of building products by careful product design (Abel, 1988, p17).

Another influential group named Archigram, assembled in 1961 and put on seminal architectural exhibitions such as the *Plug-in City* by Peter Cook (1964) and *The Walking City in New York*, by Ron Herron (1964) - shown below in figure 8. Archigram's philosophy was formed around the idea of metamorphosis, the continually changing but always existing environment. The group questioned the need for buildings at all, and suggested that in order to survive "we must invent new artifacts, new situations, and regard shelter or urbanism merely as a term of reference that does not demand a 'house' or 'city'."

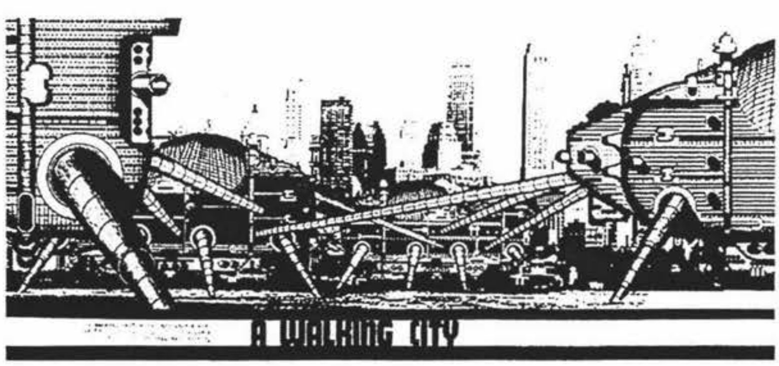

figure **8.** The Walking City in New York, by Ron Herron (1964).

Another major influence had grown from the 1960 "systems approach" and relates to the industrial building methods of the prefabricated kit buildings. A major change in thinking in architecture occurred with the factory-made Southern Californian Schools Development project, or SCSD by Ezra Ehrenkrantz in the 1960s. Ehrenkrantz had no skill in factory production methods, so the factory designers developed the system for production (Abel, 1989).

Sudjic (1986) pointed out that Rogers, Foster and Stirling, have in different ways, continued to work in what can only be called a "modernist mode", albeit one that has radically widened its concerns from the pioneering days of the 1920s. The potential of the modernist is also exhibited by present architects such as Mario Botta in Switzerland, Arata Isozaki in Japan, Hans Hollein in Austria and many others.

Norman Foster and Richard Rogers met in 1961 while studying for their Master degrees in Architecture at Yale, where they were taught by Serge Chermayeff, who helped pioneer modernism in Britain. At Yale they were exposed to the work of Serge Chermayeff and Christopher Alexander described in *Toward a New Architecture of Humanism*, which propounded an "ecological approach" to architecture and urban form, and had a similar rationale to the "interdisciplinary system" approach. The work of Chermayeff and Alexander differed from the purely technological orientation by emphasizing the aspect of "human ecology". This was also the philosophy of Buckminster Fuller (Abel 1988, p13). Foster and Rogers joined to become "Team 4" with two other partners from 1963-67, and designed mainly houses. The work of Foster and Rogers are presented as examples of architects who create and produce total environments of the Second Machine Age. These two well respected firms are presented below because they are the forefront in their field, of course there are others such as Grimshaw + Edwards, who have equally integrated working methods, but tend to a lesser extent get involved with 'spin-off' commercial products.

Foster and Rogers Development of Products in Architecture

The involvement of product development in Foster and Rogers methods is in fact part of their philosophy and approach to building. Sudjic (1986, p43) explained that Foster Associates has been concerned since its conception by projecting the image of the "architect as the omnipotent scientist, committed to team work and efficiency, and adopting the most technocratic of working methods". To realize truly integrated design solutions there is a need to broaden the range of skills and to emphasize team work.

Today factories manufacture practically all components of a building by common production methods, but with little or no involvement from architects. It is in this situation where Foster and Rogers excel while others remain detached from common place production processes and methods. By realizing that items are produced when ordered, these architects have learned to work with manufacturers to modify their product to suit a particular job. This also creates a situation were by understanding the processes, they are able to develop and produce spin-off products which increase the range of products available for specification by others. Both Foster and Rogers have, through the use of development programs, pushed technology and manufacturers to the maximum, as is the case with the Hong Kong and Shanghai Bank (Foster) and the famous Centre Beaubourg, or Pompidou Centre, in Paris (Rogers with Renzo Piano and Sir Ove Arup and Partners).

Philosophy and Working Methods

Both Rogers and Foster developed early in their careers an aversion to conventional building processes, which they considered to be muddy, inefficient, inexact and for the builders themselves a cold, wet and unpleasant task. A fundamental aspect of Foster's philosophy is that with the advent of the Second Machine Age, specialist components and one-off designs are able to be manufactured at minimal cost. Foster places high priority on cost control and program disciplines as a framework to control quality and to attempt innovation.

The extent to which Rogers and Foster are prepared to go in the process of invention is an integral part of their methods of design. Their approach is underpinned by a willingness and ability to extract from manufacturers, performance that is often beyond the limit of what is normally considered possible, by becoming involved in the factory manufacturing process (Sudji, 1986, p75).

Both firms maintain a permanent staff of model-makers that produce mock-ups and prototypes for study and evaluation within the office, developing form simple hand cut polystyrene shapes to a metal casting as shown in figure 9. This has the added benefit of giving the firm the ability to be able to talk to manufacturers on equal terms in regard to methods of production. Foster demonstrated that by working with people in industry and studying the essentials of production technology, it was possible to design components for relatively small production runs suitable even for single building projects. Foster often designs components with the possibility of wider use in the building industry in mind, even though they have to be justified within the constraints of a single project (Abel, 1988). Foster designs out the surprises, the same way a car manufacturer constructs a maquette of a new car before committing to full production.

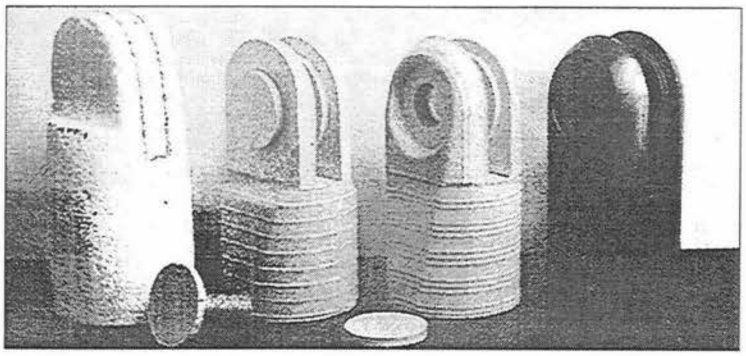

figure **9.** Model development for casting. Richard Rogers + Partners.

For both Rogers and Foster, the initial design of a building tends to be a diagram, almost an agenda for discussion, rather than a final design, even though that is often how it is presented. Thereafter teams within each office are detailed to investigate all the technical options available for realizing particular areas of the building. Specialists also have to be involved right from the start. Without them the high level of technical sophistication that Rogers and Foster both aspire to would be impossible to achieve (Sudjic, 1986, p74).

Both Architectural teams use the services of the engineers Ove Arup and Partners and other specialists when working on a design and build program of work. This approach to work also means the firms get involved in wide ranging work including materials research with large manufacturing companies such as Pilkington Glass. In the design for the Hong Kong and Shanghai Bank the Foster team used a new approach to the design and development process. What distinguishes the new approach, which Foster refers to as "design development", is its similarity to industrial design rather than to conventional architectural practice. Almost all of the components used in the bank building were designed by the Foster team in close collaboration with the manufacturers' own design and shop floor people, an exhaustive process which included the making and testing of full prototypes. (Davies, 1986, cited by Able, 1988).

Foster and Rogers are both considered to be or are labeled 'high-tech' architects. However they have proven that they can work with low tech regional materials such as the case with Foster's housing project for the Televisa Headquarters Building in Mexico City by building within the limits of local construction techniques and materials. This stresses Foster's interest in "appropriate technology". Perhaps a more apt description is that they strive to explore and use materials and processes to create effective projects. They ask the questions 'what if' and 'why not' to expand and develop what they view as an archaic industry by using combination of methods, research and professionals to achieve good design. They are architects who understand the overall picture which includes not only the spatial and construction qualities of buildings but also the importance of details such as lighting and furniture which are indeed part of the overall picture.

Design of Furniture in a Building System

This section outlines the design of furniture for a large public building where constraints meant that there were no existing commercially available designs to fulfill requirements, thus a product development program was initiated.

Use of Manufacturing Methods. The Furniture for the Centre Pompidou Paris, France 1974-76, for the client - Ministère des Affaires, Culturelles/Ministère de l'Education Nationale. The development team included the Architects Piano + Rogers, with the internal systems group of the Etablissement Publique du Center Pompidou.

A special edition of *Architectural Monographs* dedicated to Richard Rogers + Partners reports that this project was initiated because of the quantity of material required, and the absence of any available system on the market capable of satisfying the diverse range of user needs. This led to an early decision to develop an integrated range specifically for the Centre Pompidou. The aim of the project was to develop a coordinated kit of parts that would be easily adaptable to all the internal needs of the building, and be capable of producing a consistent vocabulary of furniture that also fitted the construction vocabulary of the building, as shown in figure 10.

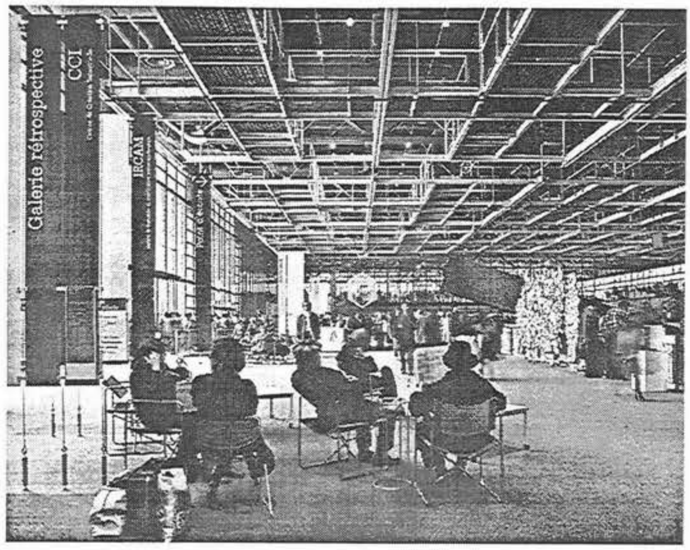

fig. **10** Interior view showing various chairs and the signage system

The kit of parts had to respond to the changing needs of the building and users, and it was essential that the parts could be easily assembled and taken apart without resorting to specialist assistance. The kit of parts consisted of: a table and work station system; a chair system; and a suspension frame system for display. Single components, capable of being assembled to produce different items of furniture were developed wherever possible to minimize the range of components and offer economy of production. The ability to knock-down all components in the kit to component level was important and meant a reserve would always be held in stock.

French fire codes ruled out timber and any form of plastics except for small parts, so this led the system of construction to metal, and in response to the low overall budget, steel was chosen compared with aluminum. Time and cost constraints dictated the use of simple production techniques to supply the large quantities of components required. Therefore processes such as brake pressing, stamping, spot-welding and weld-mesh influenced the design process, as shown in figure 11 for the seating.

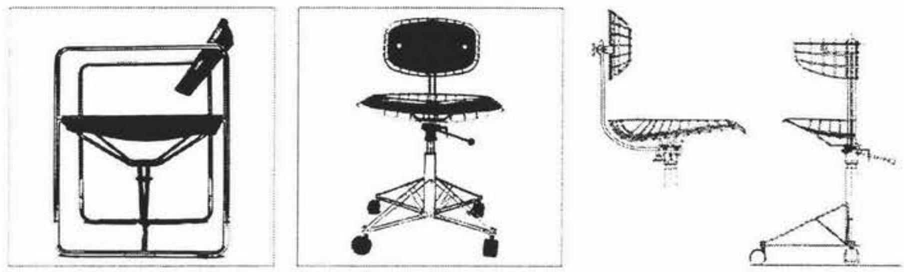

figure **11.** Seating for Centre Pompidou.

Evolutionary Development of Furniture

The Nomos Furniture System by Foster Associates for Techno, Italy is an example of a product that has undergone evolutionary development through three projects. It is an example of a mass produced main-stream product system developed between an architect and manufacturer.

Sparke (1989) outlined the development that led up to the Nomos range of furniture by Foster Associates. The final Nomos range evolved through two projects, the first was drawing desks designed and manufactured for the Foster studio in Great Portland Street in 1981. The impetus for the development of the desk was the problems the firm found in the available off-the-shelf models including they were too heavy, expensive, inflexible or had a long delivery time. A brief for a design to counter these problems produced the use of a tubular-steel sub-frame and a special mechanism that allowed the desk to perform multiple functions - see figure 12. The brief also anticipated that variations on the desk might include a storage facility. The real key to the desk was the invention of a honeycomb-cored table top which drew inspiration from aerospace technology. The development work was undertaken through a process of sketching, working on full-size mock-ups and providing a prototype which was presented to the manufacturer. These desks were essentially 'batch production' objects manufactured in small numbers with hand processes such as welding.

figure **12.** Nomos evolution Stage 1. drawing board design for the Foster office.

This basic design was then extended and developed into a range of simple office furniture that would visually and conceptually blend with the Renault Building, an architectural project undertaken by the office in 1983. The design of the desks was changed to suit the manufacturing processes for a job this size by including a simple casting, although the main manufacturing process was still welding as in the initial design. The Renault furniture included a desking system, glass-topped dining tables and extra adapted pieces such as the reception desk shown in figure 13.

After the office desk and Renault building furniture were completed, Foster decided the furniture should become main-stream furniture. Foster chose an Italian furniture manufacturer called Techno to work with in developing the Nomos range. Once formal contracts had been drawn up, development work progressed rapidly and the prototypes of the new system were on show at the Milan Furniture Fair of 1986.

figure **13.** Nomos evolution Stage 2. the Renault Building reception desk.

Design for Manufacture. The Nomos system required involvement from both the Foster and Techno design teams in the development stage for production and included issues such as: production feasibility, ergonomic and mock-up testing; and the development of design details. For mass production, the problem of reducing the welding involved in the earlier designs was solved by creating a number of cast-aluminum pieces which act as joints linking one piece of steel to another. This in turn meant that only the steel tubes needed to be cut to the various lengths which increased the flexibility of the system. These castings were vital to the production feasibility of the system, and much work was undertaken to perfect them as shown in figure 14 - *a,* the initial sketch, *b,* a two point fixing method, *c*, an aluminum prototype of four point fixing, and *d*, the final solution shown with half of the production mould.

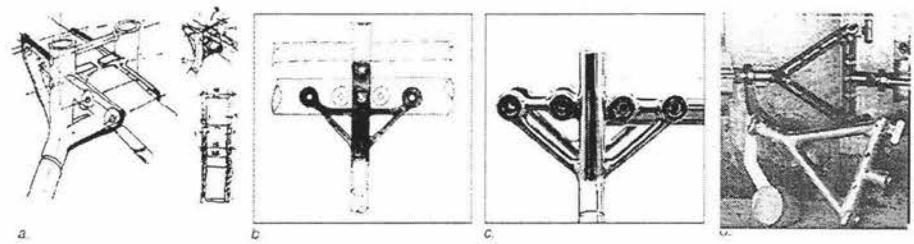

figure **14.** Nomos furniture. Casting system for leg detail.

Although radical changes were made to Foster's designs, they did not damage the original 'feel' of the early concept as figure 15 shows.

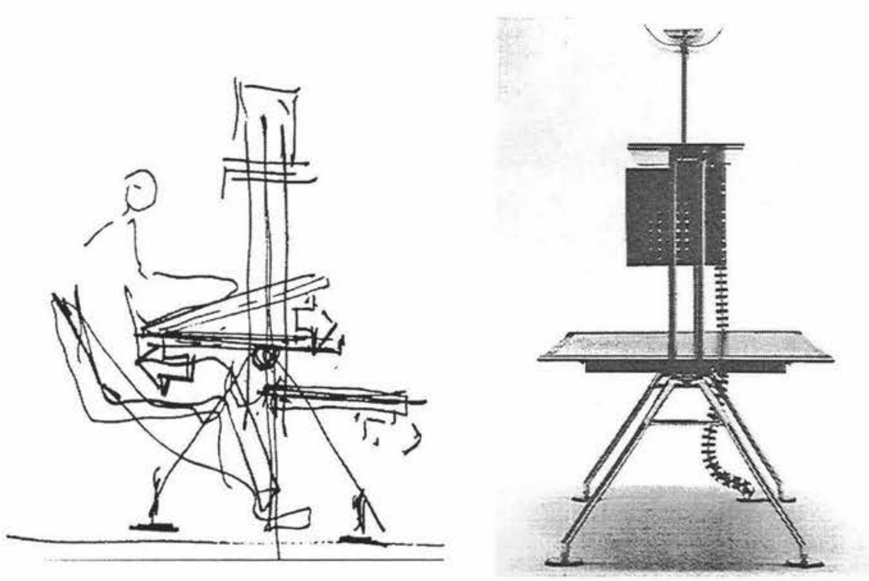

figure **15.** Nomos desk - initial sketch and finished product.

Ergonomic testing was an important factor in the development process - see figure 16c. Mockups were used extensively throughout the development process. Two possible support structures in figure 16*a* & *b* were explored and developed concurrently for some time before a decision was made to go with option *a*.

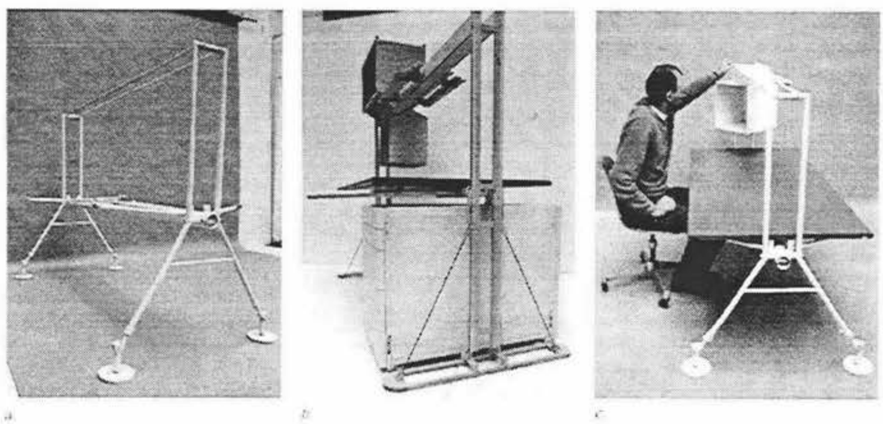

figure **16.** Nomos furniture - mock-up and ergonomic development.

Development of configurations were explored including the provision for wheels and leveling adjustment. The final foot detail incorporating these features is shown in figure 17. Mock-up testing was also carried out during the detail production stage at Techno as figure 18 shows, for fine tuning before committing to production.

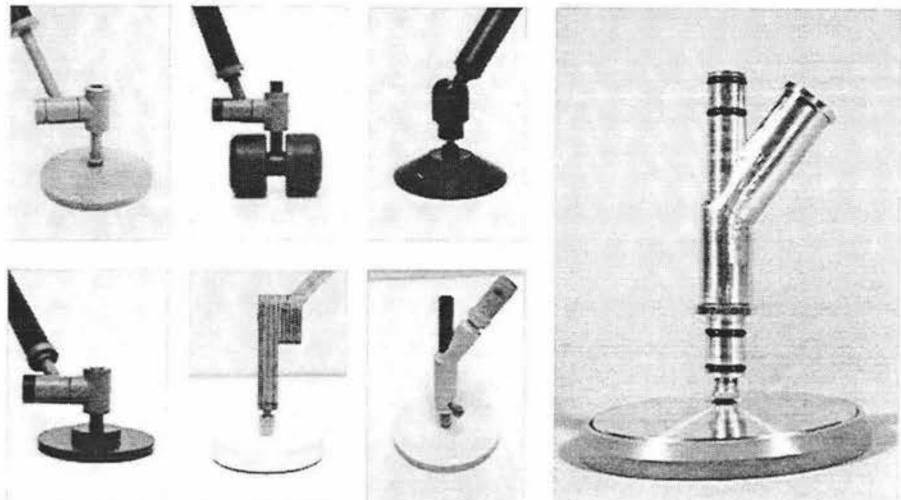

figure **17.** Nomos furniture - Development of the foot detail.

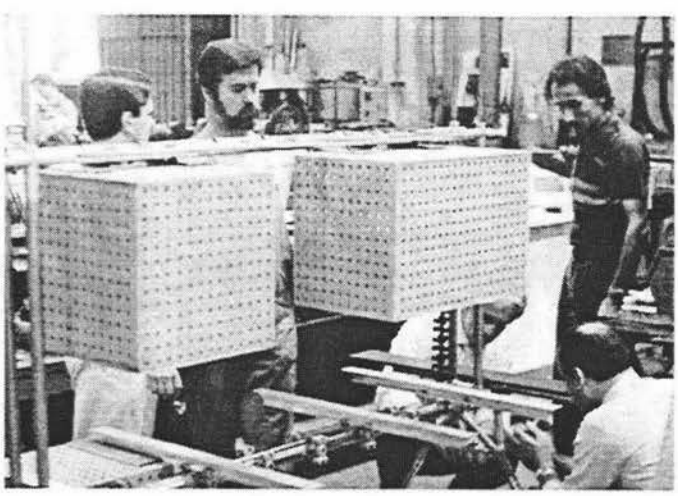

figure **18.** Nomos furniture - Factory mockup testing of designs for storage.

The highly organized, flexible manufacturing system that Techno developed has proved ideal for the production of Nomos, as it depends upon a variety of standardized and individual components which can be put together in a number of different ways. Techno's role did not end with production - its in-house design team was responsible not only for some of the development work for the system but also for its packaging and publicity material. An innovating package was devised where by the steel spine provides support, thus making the package light and compact. Techno, in keeping with the kind of work it has undertaken in the past also offered a service to customers for the design of office layouts, and offers them a book of configurations of possible layouts which brought the project to a logical end.

Integrated Teams

In 1975 Roger's PATScentre was founded and includes a multi-disciplinary team of engineers, architects and scientists. It was formed with the aim of extending the team's understanding and expertise to effectively integrate the potential of the Second Machine Age to shape an environment which offers to the user the full advantage of these new technological forces (Architectural Monographs, 1985 p138). PATScentre research includes environmental systems research such as: acoustics, lighting. space servicing and materials research, prototypes, mockups and performance testing.

Both Sir Norman Foster and Sir Richard Rogers are much respected for what they achieve, and are very much figureheads and spokesmen of British Architecture. One important issue often overlooked by reporters on these two truly multi-disciplined top international firms is that they do still work closely with manufactures at home that are producing products that could become export earners for Britain.

Total Design Approach

In order to produce environments that are successful, there must be a total design approach. The total design approach emphasis an understanding of the methodology utilized, and the manipulation of that process; an understanding and inclusion of the different discipline skills involved; and knowledge of production methods.

Abel (1986) suggested that the potential of new building technology cannot be fulfilled unless changes are undertaken in architectural practice and education more along the lines of industrial design practices. This may be a worthwhile advance but the gestation period could be as much as 20 years by the time the students of this era are in a position to implement their altered practice methods due to the conservative nature of architecture. Perhaps a more responsive approach would be to utilize the industrial designers presently available, but also educate/promote product development as a multi-disciplinary approach: working with manufacturers to achieve results that incorporate and maximize craft and industrialized production methods for the building industry to progress.

Communication and teamwork are obviously two of the key ingredients to the success of these projects. Other factors include the innovative personality of the team leader. An understanding of process and production methods is necessary so that research and development teams understand were they fit into the process and feel comfortable to push manufacturing processes. The processes and practices used have been developed to optimize to reduce the development risk of products within the architectural industry. This approach is changing the industry expectations to bring it up to speed in the Second Machine Age, and in line with Le Corbusier's 'Machine for living' philosophy. The examples above of leaders for what should be a more widespread industry standard, although it should be stated that not every architectural firm will have the necessary expertise to get involved in this type of work. However the firms already working in this area should understand the product development process, the commitment involved and be prepared to take the risk associated to the larger projects.

In New Zealand there are examples of architects who develop products with manufacturers for a total design approach. One such example is a stadium seat which was developed and produced though a strategic alliance between Metallion Ltd. - an architectural product accessory manufacturer, and Reese Plastics. The project was initiated by the manufacturer while the stadium was in its initial development. The architects were involved in feedback and evaluation sessions throughout the development of the seat. The design was accepted for tender in its final model stage. The development team was made up of industrial and product designers, a model-maker, and the two manufacturers. Brown (1996, p35) from Metallion Ltd, the project manager of the development project said "The key to successful team development is encouraging creativity, while still maintaining focus on the commercial goals. At times, these can seem contradictory". To this end Metallion put together a development path model which was applied to the new stadium chair project. The model breaks the various stages of development into two types of tasks - creative and analytical so team members can understand the nature of the tasks and work in the appropriate thinking style.

New Zealand shelving manufacturer Hydestor won the tender for the development, production and installation at Wellington Public Library in 1991 of a new shelving design, designed by the architects. The library shelving project was initiated when the architects were despondent with the four available existing systems on the New Zealand market, the design of which was 30 years old and did not meet the requirements for storage, wiring, lighting, and signage. Hydestor's Royale library system has a display function and was especially designed to carry internal wiring and the cable management facilities necessary to service communication technology. The design also included a combination of possible storage systems for books, CD, magazines, music cassettes and posters. The development took place over one year and cut $250,000 off the original budget due to the improvements made. Other total development work by architects include the New Zealand Rail long distance train upgrade and the National Bank of New Zealand, work that was undertaken by Custance Associates. The examples of projects above have been initiated in several ways including: the lack of commercially available products; the present products do not fulfill the specifier's requirements; a tender situation has created a new design. Another possible initiation is by an architect or manufacturer with knowledge of up-coming project.

A NEW ZEALAND CASE STUDY

Chapter Three

Product Development in a New Zealand Architectural Project

This case study presents the design, development and decision process of a development project within an architectural environment. The project, the design and development of a library trolley system for the new Palmerston North City Council (P.N.C.C) Library completed in 1996, was in conjunction with Athfield Architects of Wellington.

Introduction

The trolley system comprised four trolleys: standard, technical, display, and book return, and was based on an existing standard book trolley, produced by a Wellington Manufacturer for the Wellington New Public Library in 1991.

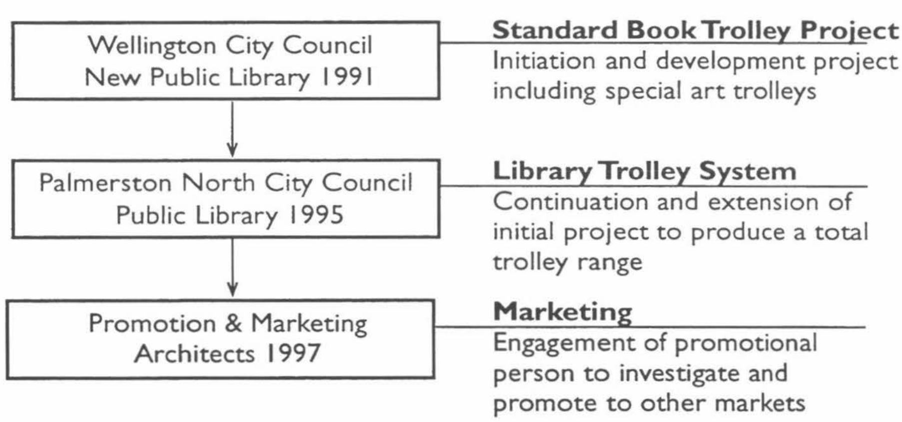

figure **19.** Evolutionary development of a library trolley system

An overview of the Palmerston North project is shown using stage, decision, and feedback models imposed over each other. The procedure is outlined, and a background to the project is given. The background section overviews information from the initiation of the first trolley project in 1991. The study then outlines the Product Development program for the total trolley system. A timeline with key points is also included, and relevant issues such as the decision process, project cost and resources, design investigation, testing and user participation are outlined, summarized and discussed.

Aims and Objectives

The aim of the project was to design and develop a trolley system for a library environment based on the existing trolley design with an emphasis on user testing during the development process.

Major objectives in the brief included:

- to design and develop a system to enable sustainable production for the manufacturer of the product.
- to utilize manufacturing methods not available in single job production runs.
- to research new materials and processes that could be utilized in the production of a trolley system to create an unique product.
- to foster an understanding of the legal issues and property rights involved with such a project.
- to evaluate the potential of the system as a generic product in the market, both local and international.

Criteria for the design direction at the initial stages consisted of manufacturing simplicity, cost, and a visual language linkage of the environment and products within the system. A complete brief for the project can be viewed in appendix A including criteria and resources, and in appendix B there is a time line.

The Product Development Process

Table 2 shows the steps in the development of the trolley system for the P.N.C.C. library. The main development stages and techniques are shown, The action and decision process shows the direction the project took in response to the decisions made by the architect and client.

Table **2.** The product development process for the new trolley system for the P.N.C.C. library.

Stages	Activities and Techniques	Action and Decision Process
Planning	- project briefing and planning - meetings and feedback as required - discussion and understanding of previous project - recognition of pitfalls and evaluation of previous project - design knowledge completion	Go ahead from client. Identification of areas for product improvement and innovation. Formulation of product development plan Definition of project, timeframe, resources, intellectual property and fee setting.
Research Problem Identification	- observational photography and note-taking - user assessment of existing problems/designs - system evaluation and analysis	Analysis of system for direction Special designs registered on schedule
Design Specifications	- meetings and feedback - working brief	System definition
Design	- discussion drawings - mock-ups	Design philosophy specification
Concepts	- conceptual drawing and sketching - presentation drawings - initial specification sketches - meetings and feedback	Critical analysis of concepts and system Determination of technical feasibility and cost
Mock-up	- prototyping where necessary, within budget limitations - in-house user evaluation of product within system	Approval for development of prototypes and budget Product improvements determined
Testing - User	- meetings and feedback - general feedback - public user evaluation questionnaire and feedback - specific user evaluation feedback	Analysis of consumer and technical evaluation of product prototypes
- Technical	- meetings with manufacturers - feedback from technical experts	
Tender	- discussions with draftsman - specification drawings - tender documents - notification to manufacturer	Notification to interested parties Tender analysis and selection
Production	- supervision of manufacture - meetings and feedback	Adjudication on alteration of manufacture
Delivery	- revision drawing and notification	Inspection and handover of items

Planning

The planning stage of the project consisted of "brief" writing and project planning. Meetings with the architects were held with the designer to plan the project in terms of resources, time and fees. The possibility of development work for the new trolley system was undertaken with the Wellington manufacturer regarding resources and a prototyping budget. The previous project was discussed to evaluate it and recognize the pitfalls of the development work.

There was a high proportion of R&D in the development of the Wellington trolley, and the new P.N.C.C. Public Library was seen not only as an opportunity to meet the requirements of the library but extend the range of trolleys. The potential in the design for sustainable manufacture and marketing to other libraries and similar environments was also discussed.

Research

This section outlines the research stages of firstly the standard book trolley and then the new trolley system.

Standard Book Trolley

Previous development work for the standard book trolley in 1991 is outlined in the following diagram.

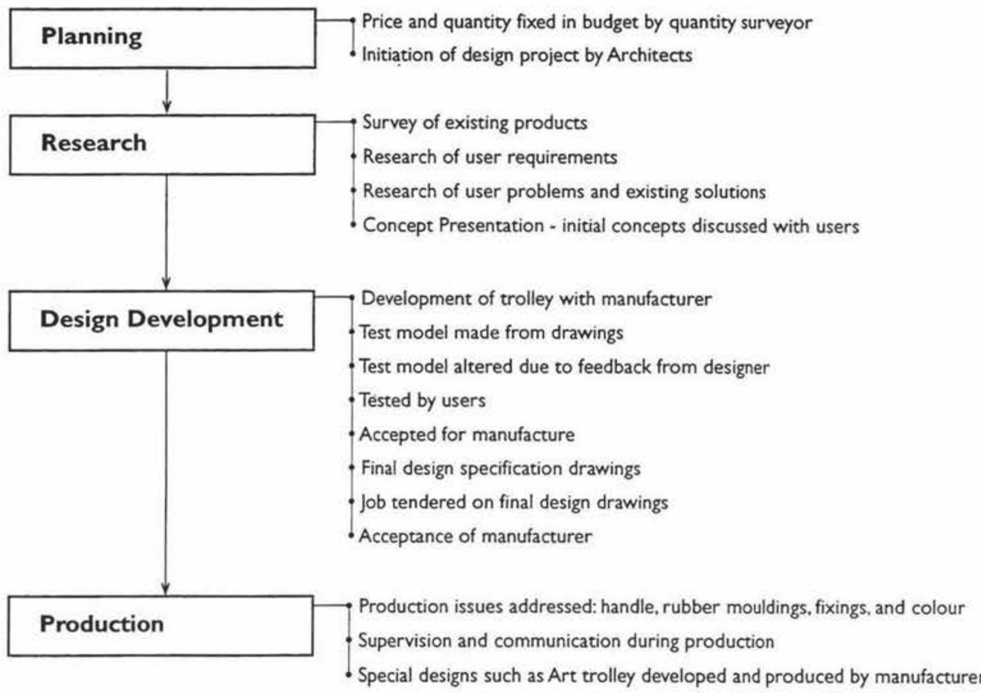

figure **20.** Standard book trolley design project for the Wellington Public Library.

Technical Information. From the start of the project it was envisioned that the trolley designs be based on the standard book trolley, produced by a Wellington manufacturer for the Wellington Public Library in 1991.

The manufacture followed the existing standard trolley, with some changes to materials and finishes due to the design philosophy for the new environment, and feedback from the Wellington Library staff. The changes included: a colour change of the handles and shelf tops to suit interior scheme; the density of the foam handle was increased due to wear on existing trolleys; and as the interior did not include fine perforated steel, the steel end panels of the trolley changed. Rubber bumpers at the base of the frame were excluded because of problems in fixing the silicon based rubber to the steel. This was not seen to hinder the trolley's performance as the handles were the major impact zone bumpers.

User Feedback. User feedback was gained from the Wellington library staff after four years of using the trolley. The original design of the trolley was assessed in the areas of material selection and use. The staff found the trolley to fulfill all their needs of a standard book trolley, and could not offer any improvements except in the areas of material selection as mentioned above regarding the wear on the handles. Several of the handles had been replaced because of deterioration, but this was expected due to the high use and impact of the trolleys over a four year period. The replacement cost or the handles is 50 dollars a pair and is seen as a design advantage to replace them rather than purchasing a new trolley.

After feedback from the Wellington staff the changes to the standard trolley were discussed and agreed upon and then recorded on the finishes schedule. Thirteen trolleys were ordered from the manufacturer of the Wellington trolleys. Twelve of these trolleys were given to the P.N.C.C. staff to use and the remaining trolley was given to the designer to work with up to the mock-up stage of the project.

Summarized below is the feedback on the initial delivery of the standard book trolleys, used for four weeks by the P.N.C.C. staff in their existing workplace. The twelve trolleys delivered to the staff created mixed feelings and feedback. These ranged from total dislike to acceptance as can be seen in the response notes in Appendix C. The main comments can be summarized as: the need for a central divider; the trolley is too shallow; the preference to height varies; steering - pulling to side; bottom shelf too low; larger and wider wheels for use in the lift .

The height of the trolley was mentioned at a meeting whereby two 5'3" staff members complained that the trolley was too low to push comfortably and requested the handles be raised. However a 6'5" staff member found the handle height acceptable. Changes after this meant the remaining (around 70) standard trolley order included raising the handle uprights slightly so that books could stack against the uprights and not slide down. This did upset the new trolley system slightly as there are 13 short trolleys, while the rest are taller, and both kinds circulate all throughout the library at the same time. These comments may reflect the uncertainty and angst the staff were feeling at the time.

New trolley System

Research for the new trolley system included:

- the compilation the design knowledge from the previous job
- an evaluation of the existing products and system
- an investigation of user requirements for each trolley in the system
- a study of the environment in which the system will fit into
- an investigation of the potential market size for the products

Technical Requirements. The trolley project had a number of technical requirements which had to be researched including:

- a search for the standards involved with electrical connections on movable items in public spaces
- the standards involved with electrical connections on movable units
- signage and wiring considerations.
- the fold away trays, keyboards, and other moving components on the trolleys
- the possibility of using existing commercially available components
- the footprint size of products to go on the technical trolley presently and in the future.
- security issues of the items on the trolleys

An understanding of the existing circulation system of the trolleys and how it would change in the new building was discussed at great length with the Head Librarian, Library Manager and Architect, but was not confirmed. It was concluded however that the aim of the trolley system was to provide library staff and users with a flexible adaptable system that would meet the requirements of the ever changing environment of the library.

The anthropometric data of sitting, standing, and wheel chair dimensions associated with VDU equipment and furniture were addressed for the technical trolley. Commercially available components for supporting and adjusting the keyboard were investigated. None of them were intuitive about their operation and this proved difficult to choose the required component for a public product where a wide range would be computer furniture illiterate.

User Investigation. Staff at the existing Palmerston North Library who use trolleys were individually interviewed to understand their requirements and problems associated with the use of their existing trolleys. This information was recorded in note form and through the use of photographs. Any special trolleys required by staff such as a shorter trolley with one handle to move boxes were added to the architect's schedule of quantities at this time.

An occupational issue was raised while interviewing the staff concerning the over-stacking of the standard book trolleys. Due to the lack of available trolleys or by waiting too long before the books go out to be reshelved, back strain and the chances of the trolley tipping over were more likely to occur. The system was improved by increasing the number of trolleys in use and also explaining the correct method of handling a trolley.

Market Information

A brief investigation was undertaken to ascertain the total number of Libraries in New Zealand and Australia consisting of Public, Branch, Private and University Libraries. However it became apparent that the 'system' of the library was the information required. The system, as termed by Librarians reflects the circulation numbers and procedures for libraries and from there an approximation of trolley numbers can be obtained. A rough indication was that Palmerston North library is a medium-low system and required approximately fifty book trolleys.

An extensive assessment of existing trolleys and related products was undertaken in 1991. This highlighted poor quality design, manufacturing methods, with a high price tag and low New Zealand content in the range available. The potential in the design for sustainable manufacture and marketing to other libraries and similar environments was discussed with the design team. It was envisioned that the first three trolleys of the range could be utilized by parties outside the library environment, such as book shops and offices.

Design Specification

After information gathering had been completed and evaluated, general criteria was set for the range, as well as for each trolley to aid in the design investigation stage of the project.

General criteria of the trolley system were:
- meeting the ergonomic requirements of users
- providing protection to the environment and trolley users
- allowing free movement by specific wheel selection
- requiring a minimal need for refurbishment
- allowing an easy adaptation to frame structure in production for the whole trolley system

Individual Product Criteria in the areas of ergonomics, technical requirements and product use were developed for each trolley in the system as follows:

The **standard book trolley** is primarily used by librarians to transport books to and from the shelves and for use in new book processing and repair operations.

The **technical support trolley** is used by the public and library staff. The trolley was to provide support for technical equipment such as: television and video; CD ROM and microfiche; and on-line terminals and printers. Provision for power from external source and signage was required as the trolleys would be moved around. This trolley also had to meet the ergonomic requirements of sitting, standing and disabled users.

The **display trolley** was envisioned for use in small living rooms (sections of library are split into living areas) and would be used in conjunction with display screens. The top shelf of the trolley would be used for display of books and special feature displays by community groups for example; the local herb society could provide a display of real plants that would be held in the gardening living room. The provision for display of flat work and signage was also a factor for this trolley as it would be moved to suit the changing interior.

Book return trolleys that collect books, tapes, cassettes and records would have the basic frame adjusted to take standard bins or bags for collection and movement of returned books from the after hours slot.

Some of these were later dropped due to discussions with the client or changes to budgets and programs, such as the microfiche being housed in a separate room.

Design Investigation

This section presents the design development stages in the project and outlines the feedback and evaluation of each stage up to the testing of prototypes.

Standard record keeping methods were used by the designer such as: observational photographs of the existing products and note taking of problems; conceptual drawings and documentation of ideas, plus the two log books mentioned earlier. Due to the understanding that this project was to become a case study, two log books were keep by the designer at the initiation of the project. One was used to record meetings and the decision process with the architects, Head Librarian and staff representative. The other recorded the conceptual and visual progression of the design and development of the system. This was used in meetings when discussing visual links, materials and finishes with the architects and as a sketch pad for the designer's ideas.

Design Philosophy

This had to be understood in order to design a product range that would suit the environment and context that the system was to used in, but keeping in mind the possibility of future production of the trolleys. The basic philosophy of the interior worked around the idea of the library as a living room for the city, so rather than row after row of shelving the space would be made up of smaller living rooms centered around general topic areas such as gardening or travel. The provincial setting of Palmerston North and the budget for the new library dictated the use of cost effective materials such as plywood, and simple construction methods like exposed framing and services. The philosophy was very helpful in determining design direction in such areas as; material selection; finishes; product recognition; visual language linkage of products and systems; and how users will identify with the space.

Initial Sketch Discussions

Discussion over a period of meetings with the architect and interior designer resulted in decisions about product use and systems, design philosophy, material and finishes. these were visually recorded in the designers sketchpad as the example shows below:

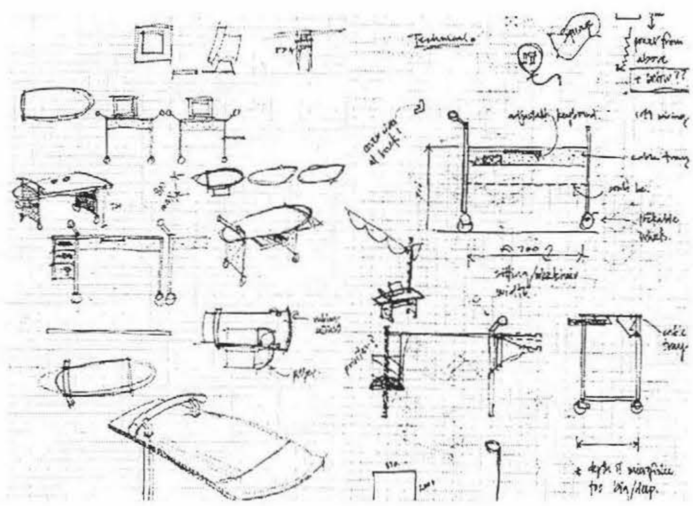

figure **21.** Conceptual discussion sketches for trolleys.

The discussion sketches were then consolidated into concept sketches for the display and technical trolleys as figure 22 shows. The concepts were presented to the Architect, Interior Designer and Head Librarian by the Designer. The Architect and Head Librarian then presented and circulated the drawings to the P.N.C.C. staff for feedback.

Feedback on Concept Sketches

Response of the staff to the concept drawings of the technical and display trolleys can be viewed in a copy of the documented feedback in Appendix D. The response to the designs was that they were not readily accepted, this could be due to the fact that the designer had not presented the ideas or that the general feelings and moral of the staff were low. The feedback showed that the staff did not understand the system that the display trolley would be part of or even view them necessary. Nor could they finalize the number of technical trolleys required which was mainly due to budget reallocation to the main contract. At this time the Head Librarian gave the go-ahead to proceed with a mock up of a technical and display trolley.

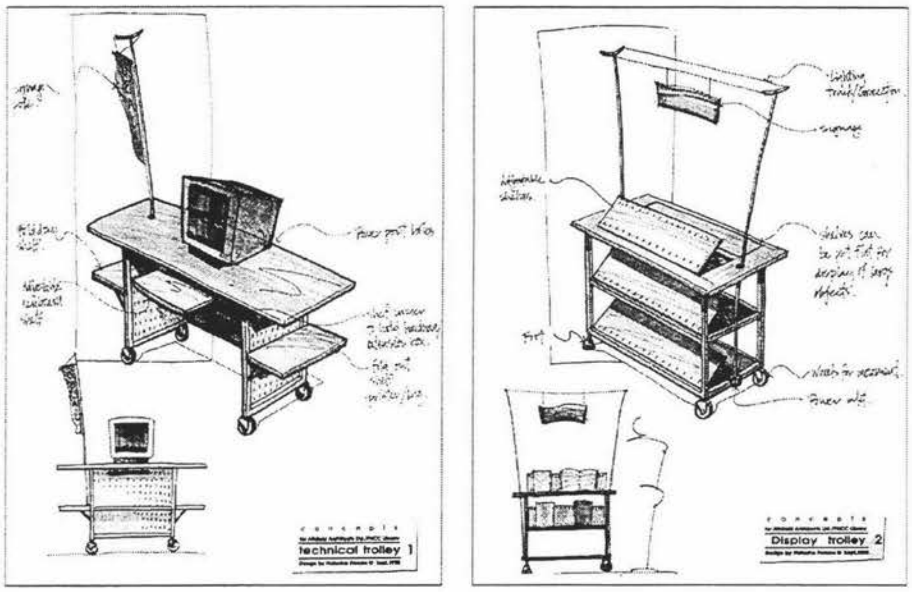

figure **22.** Concept presentation sketches of the technical and display trolleys.

Design Development

With the support of the Head Librarian the design development stage of the project was undertaken. A budget for the mock-up production was requested with the proviso that the mock-ups would be used as part of the final items after the testing was completed.

Mock-ups

A meeting with a selected local cabinet making firm already engaged in other furniture supply for the library resulted in a budget of $1,500 being set for each mock-up. The firm agreed to make the mock-ups to high enough standard to be able to be used as final products because of the cost of the mock-ups and the limited number of trolleys required.

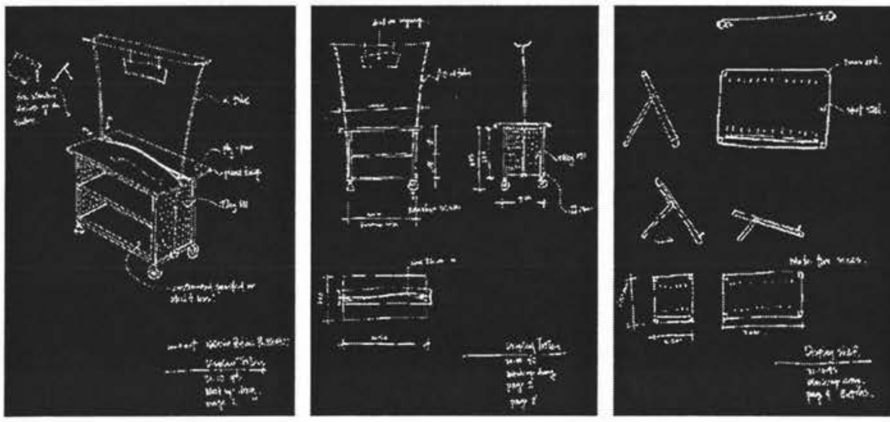

figure **23.** Mock-up sketches of the display trolley for communication with manufacturer.

The mock-ups were produced from a set of sketches as shown in figure 23 in conjunction with a standard book return trolley. A series of workshop visits were made by the designer, interior designer and architect throughout the period of production. Discussions on the shop floor with the manufacturer covered production details and cost effective component production. For example the connection of the signage post to the frame was originally cast aluminum but was changed to a milled piece of aluminum bar due to the number required versus cost.

Testing

This section overviews the testing of the technical and display trolleys with a variety of users including the library staff members, specifically targeted users and members of the public.

The Testing of Prototypes with Users. Once the technical and display trolleys had been completed, they were delivered and placed in the staff room of the existing library. By leaving them in the staff room the staff could get used to them and an evaluation with specific targeted users could take place. The need to test the trolleys on other users and not just library staff was viewed as important because the public are in fact the end users. Also by targeting specific users the team was able to evaluate the two designs on a wider range of "use" scenario's.

Evaluation with specific users. Feedback was obtained for the technical trolley through a series of evaluations with selected users to meet the widest possible "use" scenario's. These included: a wheelchair bound person with restricted hand control, for knee clearance, keyboard and lever use; a 50 plus woman in the lower 5th percentile height range; a 95th percentile tall user; and a computer illiterate user.

Technical Evaluation. A library staff member with special interest in ergonomics, and the library network consultant gave feedback on technical issues in regard to plug sizes, shelf size and security as outlined in Appendix E. These changes to the mock-up were recorded on a copy of the mock-up drawing as shown below. It must be pointed out that even at this stage of completion there was still an uncertainty regarding certain key issues such as: the finishes of the trolley; the equipment that would go on the technical trolley; and where they would end up in the library in terms of positioning.

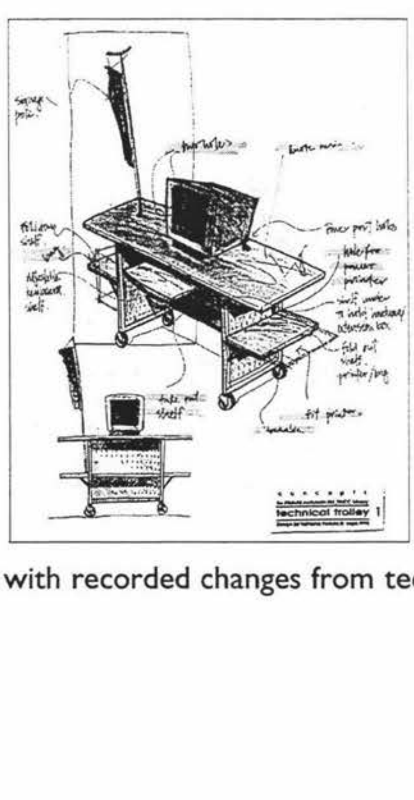

figure **24.** Drawing with recorded changes from technical evaluation.

Testing of the Trolley with the Public. The technical trolley was positioned as shown in figure 25 in the existing library for two weeks, with an on-line computer terminal and questionnaire for the general public to give their feedback and suggestions. A sample of the feedback form can be viewed in Appendix F.

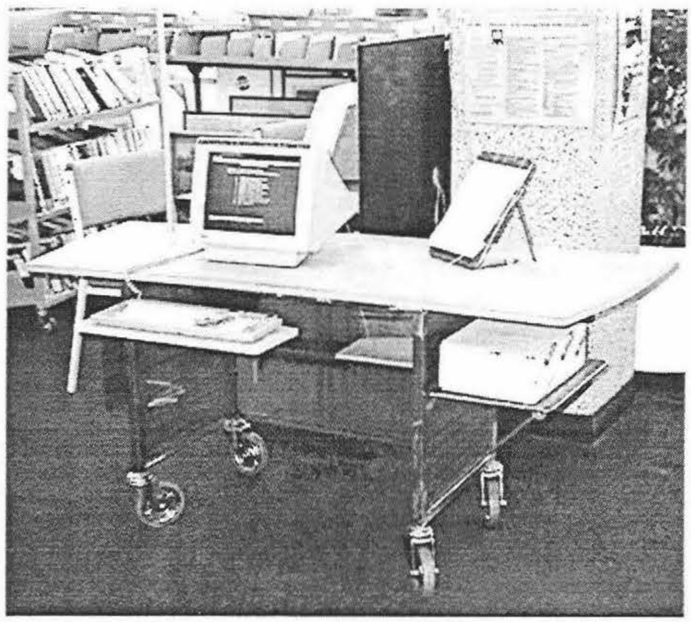

figure **25.** Mock-up positioned in existing library for evaluation.

Public Feedback Results. There were 18 responses to the technical trolley, with the time spent at the terminal ranging from two to 45 minutes. Age of the respondents ranged from 17 to 51 years.

The responses were very broad in which the designer considered 13 comments were good; 10 negative; and 8 were of a constructive or suggestive manner. The good comments covered: the aesthetic; amount of room on the top for books; and the height of the trolley. The negative responses consisted of: confusion with the keyboard shelf; the height of the screen; the quality of finish; the aesthetic; and cost compared to standard tables.

The suggestions for improvement included: the adage of pen and paper; tilting the keyboard slightly forward to improve hand angle; a better chair to sit on; and a place to put rubbish.

The public feedback proved valuable for testing the emotive qualities such as aesthetics of the design with the public. It also worked as a general introduction to the new environment which they can see being built but have no control over. There is a sense of ownership as well as uncertainty as the product they are looking at is out of its environment, as was apparent in some of the more negative reactions. It also raised points that were not brought up by the targeted users: e.g. the problem users who wear bi-focal glasses.

Production Development

With the information gained from the testing, the final specification drawing were then able to be produced. These technical drawings were drawn by one of the Architect's draftsmen from the sketches by the designer as in figure 23, in conjunction with the original standard book return trolley specification drawings. Discussion on finishes and materials, along with the structure and form of the two trolleys were conducted over several meetings. An information trolley was also sketched, discussed and drawn up for tender at this time. The information trolley was designed for one of the entrances, so it looked different but was based on the same frame structure as the others.

The designs were then put out to tender by the architects to interested parties, with a deadline of two weeks for reply. A problem arose with the existing manufacturer of the standard book trolleys, who is also the importer of the specified wheels and supplier of the handles. This manufacturer increased the cost of the specified wheels to other tenderers. After complaints from other tenderers the architect granted the use of a similar wheel to give everybody a fair chance. The successful manufacturer for production was chosen on cost competitiveness, however, due to over-commitment to other areas of manufacture for the library, they then sub-contracted the making of the display trolleys to another manufacturer. This caused a delay of delivery to site by three weeks.

Evaluation of the Project

This section evaluates the trolley project by outlining: project costs; the timeline of the project compared to the original timeframe; the communication process; and the final design.

Project Costs

The original budget set by the quantity surveyor and architects was $97,000 for 120 trolleys. This equated to approximately 80 standard book trolleys @$900 each, and $1,000 each for the 20-30 special trolleys required at that time. Primarily there was going to be a mixture of trolleys totaling 120 but this was cut back to 80 as planing progressed. The final number of trolleys put out to tender increased to 110 as the library became more aware of the planning requirements and actual layout of the space. The final tender price of the standard trolleys was $750 for the standard book trolley and $1,000 per technical, display and other special trolleys.

The designer costs and fees were minimal as the project was undertaken as a research project. The number of hours for research, design and testing undertaken in the project was estimated at 180 hrs. The mock-up costs were kept to a minimum budget of $1500 per trolley and the two produced for testing were then used in the final delivery.

Timeline of Project

The table below shows a timeline of when the major steps of the project were undertaken compared to the various stages of the building under construction, and gives an idea of the visual appearance of the building. Information regarding construction has been obtained from the architects files, recording the fortnightly site meetings between the Architects, construction company, client and subcontracting engineering and electrical consultants.

Table 3. Timeline of project and construction of library.

Project Timeline	Date	Stage of Construction
Planning & Briefing Standard trolley finishes	*June 1995*	2nd. and 3rd. floor main frame started, ground floor poured, demolition continues.
Problem identification	*July*	Demolition complete. Columns and blockwork to 1st floor and mezzanine complete. Electrical services continue.
Standard trolleys delivered to staff	*August*	Stage one construction completed - ground floor shops.
Concept presentation Feedback on standard trolley	*September*	Ramps and structural steelwork to atrium comp., Ply wood flooring laid.
	October	Glazing to atrium, undercoat painting commences, framing 98% comp.
Librarian feedback on technical and display trolley designs Prototype construction	*November*	Fixed shelving tendered. Carpet laying begins. New lift shafts completed-install. of rails + pit gear underlay, refurbishment of existing lifts comp. Balustrades installed to internal stairways.
	December	Plastering cont., mechanical ducting in progress, tiling work to toilets comp. fixed shelving underlay, framing 99% comp.
Specialist testing of technical and display trolleys Public testing of technical trolley Final design specification	*January*	Free-standing shelving contract underlay-prototype due on-site 20th. Vinyl laying, door install. and wall-lining started. Balustrades cont., plant roofs 95% comp. tiling comp. Counters contracted
Tender of manufacture	*February*	Fixed shelving-bass install. comp., units on-site. Initial assessment of free standing shelving- issues resolved. Carpentry work continues.
Tender accepted	*March*	Counter install. and carpet laying begins, painting work continues, balustrades 95% comp. Fixed shelving install. comp.
Delivery of remaining standard trolleys	*April*	Mechanical services complete, security installation, vinyl finished. Completion date 11th /practical completion 25th. Main shift from old to new library.
Delivery on-site - delay of technical and display trolleys due to reallocation of manufacturer.	*May*	25th Opening
Delivery on-site of technical and display trolleys	**June 1996**	

Relationship to original time frame. In comparison with the original gantt chart in appendix B, the actual time frames for the project are similar. The only variances were in the start and finish dates - the project was planned to start in May 1995, and delivery to site was 10 March 1996. As seen above the project started later in June and finished in June 1996. The feedback period for the concepts was slightly longer than planned, so the testing of the technical trolley was delayed. The opening of the library was pushed back due to delays in the main contract and this allowed for increased time.

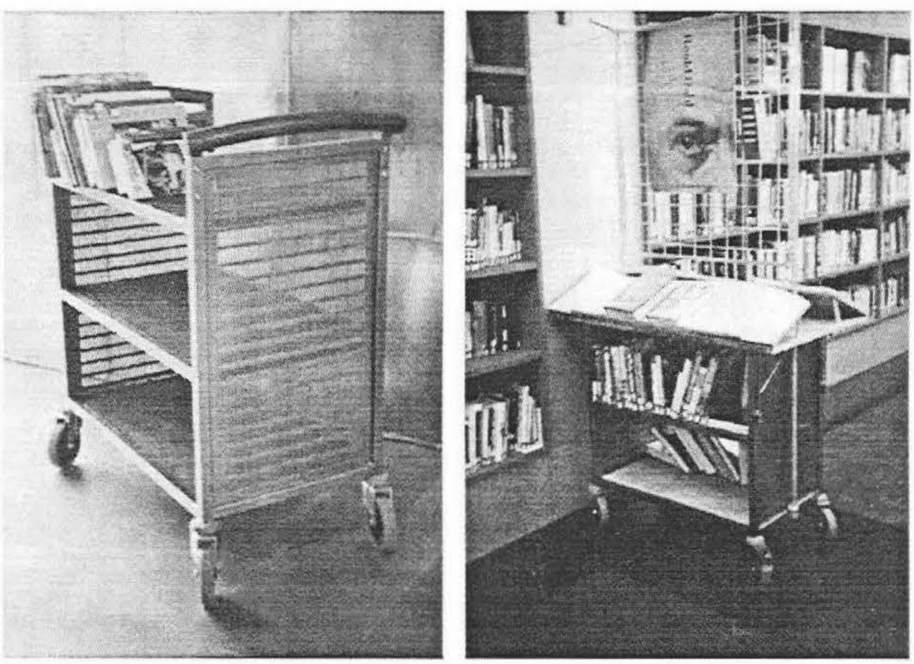

figure **26.** Standard book and display trolleys.

Final Design

The final design of the standard book and display trolleys can be seen in figure 26, the final technical trolley is shown in figure 27. Criteria for the design direction at the initial stages of the project consisted of manufacturing simplicity, cost, and a visual language linkage to the environment. The design of the system enables continued production opportunities for a manufacturer of the product range due to all the designs being based on the same frame structure. The final designs were produced by basic production methods and met the budget costs of the project. The final products in the system relate to one another in terms of finishes, but are finished with materials that relate to the purpose they perform individually, for example the technical trolley has a metal and industrial look to work with the computer equipment that they hold. The display trolley has a plywood top and shelves that relate to other plywood finished display book cases that the trolley is positioned next to in the interior.

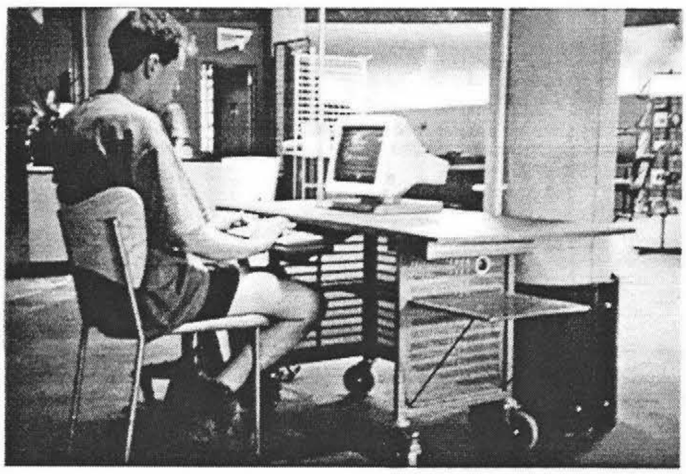

figure **27**. A member of the public working at the technical trolley in the new library.

Future Work and Promotion

A promotional person has been engaged to undertake the work required to market the product. The markets for the trolleys such as libraries, book shops, and shop retailers will be evaluated to ascertain the potential of the product range in those markets, both local and international. Promotion material and methods, distribution and support services will also be investigated. New materials and processes will be investigated and future production will utilize manufacturing methods, such as castings which were not available in the library job. The need for a specially developed keyboard shelf is required to overcome the problems associated with off-the-shelf units, and will offer a design registration opportunity for the technical trolley. Future production and marketing will also involve developing the legal issues and property rights involved the project.

Conclusions

Development in the project consisted of team work with the emphasis between the architect team and the client. Emphasis for future work will be on the promoter, the designer, manufacturer and consumer. Further development is required to produce the range cost effectively and to include features the various consumers want.

Chapter Four

Discussion and Conclusions

This chapter concludes the research with proposing the product development process as an effective method for improving the way products are designed within architectural environments with the aim of producing marketable main-stream products. The case study presented in the previous chapter is used as a reference point for assumptions raised in this chapter. Problems and barriers to this type of direction consist of: a lack of understanding of the process and the skills available; mental attitudes based in the education of professionals; time and budget constraints; intellectual property and future production; goal setting and marketing of the products; the physical size of the industry; and political - the lack of government assistance.

Discussion

The development of a product for an architectural environment is discussed including the people involved in the design and purchasing process including; working relationships; budget and time constraints. A suggested process is presented based on the library trolley project and the processes of architectural design, product design and product development presented earlier in chapter one. Future production and promotion are also issues to be addressed if this type of work is to succeed and the need to include the ownership the of intellectual property. There also needs to be someone willing to invest time and money for the promotion and marketing of the finished products once the initial project has been completed.

Lead times for the project and manufacturing need to be planned into the overall building program, so as not to leave product design and production until the last minute due to the lack of understanding of the process and management methods.

People Involved in the Design and Purchasing Process

The **users** in the library trolley system project can be divided and defined in two different terms: the librarians as technical and the public as users (end users). The users involved in the design of products in architectural environments are not necessarily the end users. Unless an effort is made to initiate end user (public) testing, the major feedback and evaluation will be by technical users (the librarians). The librarians at times rejected designs and offered negative feedback due to the change process they were experiencing .

The Head Librarian and City Engineer can be considered the **buyer** of the product. These two people place different emphasis on their requirements for purchasing the product. The Head Librarian is interested mainly in performance, while the City Engineer considers mainly cost.

The architect, draftsman, interior and industrial designer are the **designer** or **design team** in this instance. They each have a special rule in the make-up of the team - bringing experience and different skills to the project.

The **producer** in this environment is the manufacturer - they were chosen for their existing involvement in the job and had a strong working relationship with the architects. The producers obviously need to be interested in the development issues of the project, whereas other manufacturers will only be interested in receiving a finished set of tender documents to quote on. This raises two issues - firstly should the manufacturer be asked for registration of interest at the initiation of the project, and secondly should the design team need to then become familiar with the production facilities of these manufacturers before one is chosen.

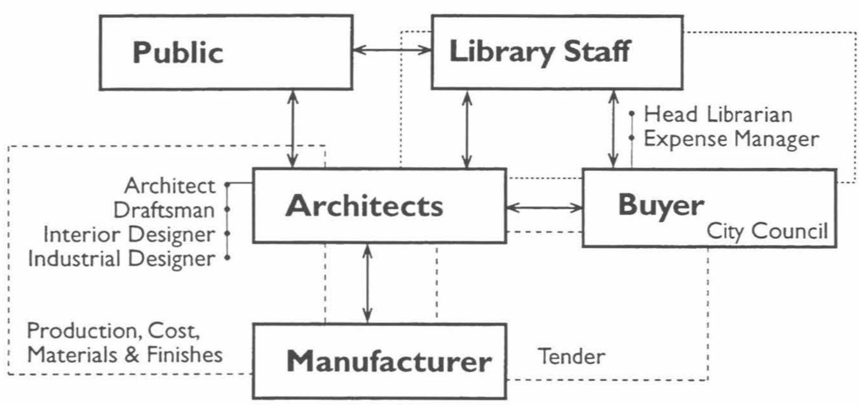

figure **28.** Coordination and relationships between parties.

The working relationships of these parties was a key factor in the success or failure of the trolley project. The Head Librarian and staff representative were the link between the staff and design team. At the time of the library staff rejecting the display trolleys, the Head Librarian made the go-ahead decision for the production of the prototype, realizing the librarians would need to see the design in real life to understand the concept of the new library. A similar decision with the technical trolley was made to give the public a chance to offer feedback.

The architect was the head coordinator of the design team and the major link to the Head Librarian in terms of communication and coordination between all parties. As specifiers of products, architects have a good general knowledge of the market but this means they sometimes forgo the need for total product evaluation. Any evaluation that is undertaken will possibly be by technical users rather than the end user. Although it can be said that analogous testing procedures in the manufacturing industry are undertaken with managers making user decisions.

Budget and Time Constraints

The time and budget for the trolley project were considered reasonable for the work undertaken. The staff were concerned at the conceptual feedback stage of the technical and display trolleys that cost overruns in the main contract would reduce the numbers of trolleys they would have. It is quite common in large building projects that money has to be relocated to the main building contract to cover cost overruns. A point worth mentioning in terms of time in the development process is that the feedback between the designer and technical users takes longer than in main stream development. This is due to the size of the job and the fact that the people involved in the process have a vast number of issues to deal with, and as in the case of the library there were a lot of participants to consider.

Budget and time constraints can be also controlled by the design philosophy of the interior. The interior designer may wish to emphasize a certain feature and simplify others which would mean budgets are juggled around to support the emphasis and development work if required. This of course has to happen fairly early on in the planning stage of the interior design so budgets can be tagged for development.

Another constraint concerning budget is that the materials selected for the product may not be the same as it would be for a main-stream product. This is due to production quantities, time frames and economies of scale, for instance the selection of the aluminum connectors on the technical and display trolleys. If there were more of them they would be sand cast and not turned out of solid bar, and greater quantities still could dictate a die-cast method.

Process for Product Design in the Architectural Environment

On the following page is a suggested process to use when developing a product for an architectural environment and includes indicators for the development of sustainable production of the products. Not all development work will be suited to future development and promotion and may just be project specific, and this decision can be evaluated in the feasibility and planning stages of the project.

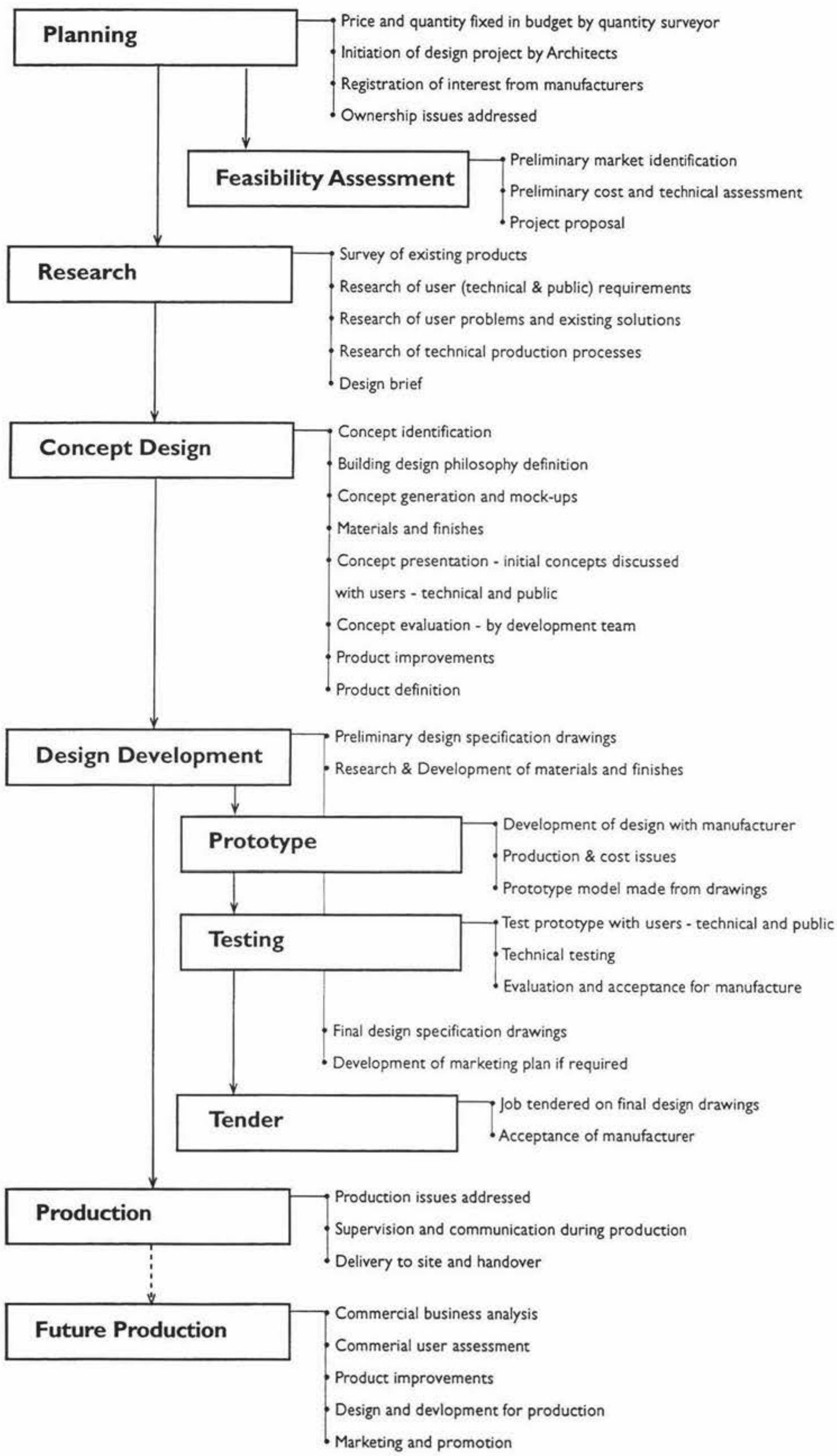

figure **29.** Architectural product development process.

This process differs from mainstream product design processes in several ways. More parties are involved such as the inclusion of the different users, which makes the process more like industrial product development than consumer product development. There is a set of end users already, but if the product is to be considered for wider distribution - then testing, feedback, and evaluation of the market and product is also required.

The process differs from the architectural process in that it stresses the need for more testing of ideas, models, and technical production issues. Also the importance of strategic planning by the stockholders at the beginning of the project, and intellectual property and future promotion issues need to be addressed if the product is considered to be a wealth generating product in the architectural industry.

As this type of development work is not the main form of income for the architects, manufacturers or client, the decision process in the development project will also alter if the product is to become a main-stream product.

Inclusion of the Product Development Process into a Building Program

The product design and development process is often involved too late in the development of a building, usually during the "fit-out" stage, and this is where product development strategies and management can play an important role. This can happen by generating interest early on, and possibly undertaking feasibility studies of markets and design at the early stages in the building program more along the lines of *stage 2* in Cooper's new Product Development Process. The following diagram illustrates where the initiation of the product development project should take place in comparison to the building program of work.

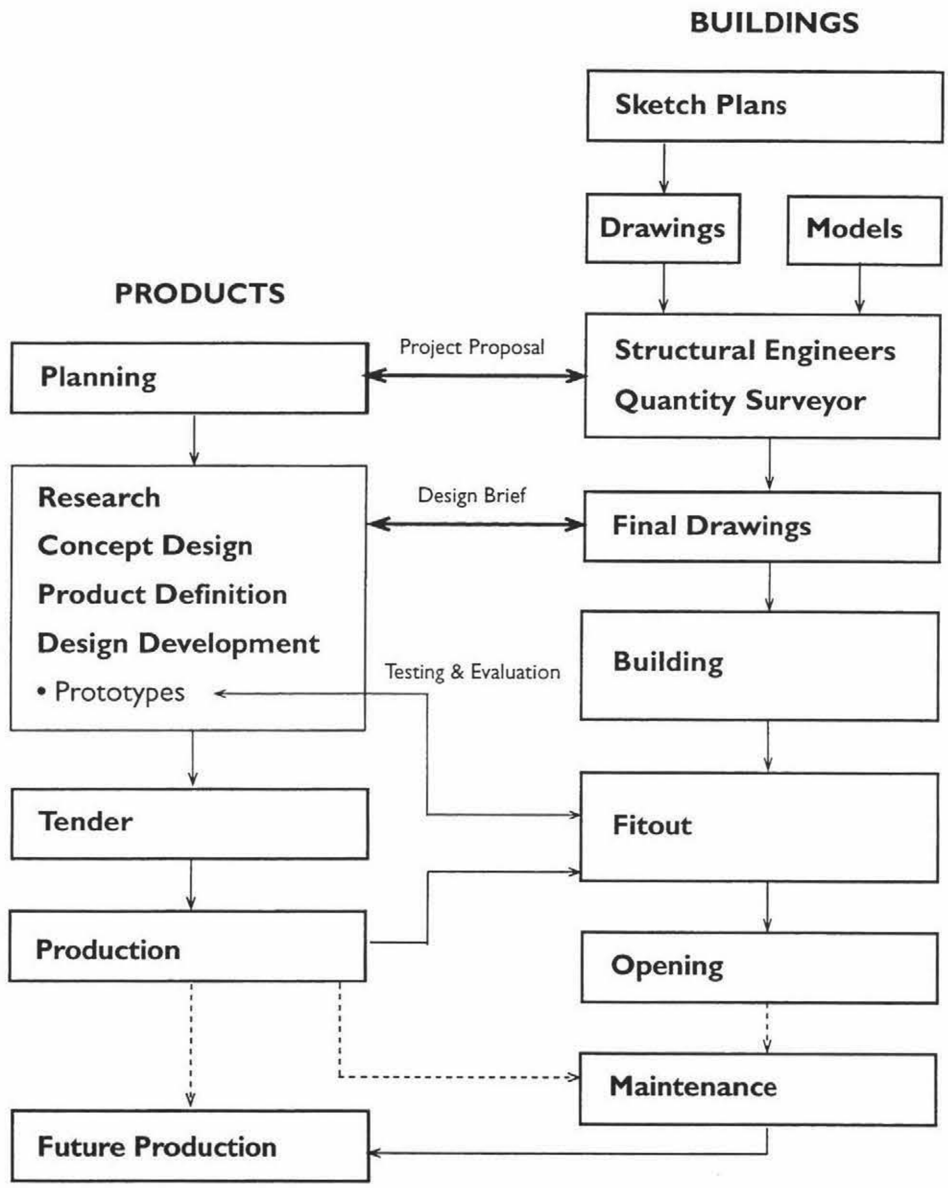

figure **30.** Inclusion of a product development project into a building program.

Problems and Barriers to the Product Development Process in the Architectural Environment.

The lack of understanding of the product design process leads to "one-of" expensive craft based designs. This can be attributed to the late program lead times, but also to the Architect's lack of understanding of manufacturing methods. However with a multi-disciplined team, and the knowledge and combination of both craft and technical production methods the finished results offer potential for development, as the work of Foster and Rogers shows. The spin-off designs need to be designed with other situations in mind and not just the interior for which the product is developed for. The products should not be so generic that they fit in everywhere, but be designed to give specifiers the option and scope to change materials and finishes to suit their particular design requirements.

The manufacturers involved in this type of process need a timeframe and goal to work towards such as a building deadline because they are primarily concerned with production and supply of existing products, and as this type of development can be time consuming they need to have a return for what is considered extra work. This attitude also raises the tender situation issue in public projects, should tender or registration be at beginning of project to find manufacturers willing to support and be involved in project.

General communication has to be set up to include all teams involved, this can be through standard methods but should include: contracts being drawn; a project proposal and design brief that contains potential market figures; testing and evaluation procedures; final project evaluation and marketing and future production. These need to be outlined so all parties know where they stand. The overall concept or idea of the development project also needs to be conveyed to the different teams. The use of models for communicating ideas is very important if team members are not familiar with this type of development work as is the case for most clients, technical and public users.

A record of the process used should be implemented, such as ISO9001 methods, as a form of communication. Many manufacturers already are familiar with the ISO9001 system and architects standard record keeping procedures are analogous with this system already, so it would not take much work to align the communication process.

Future Production and Promotion

Two major areas that require consideration and inclusion in this process that are not familiar to the architectural plan are marketing and intellectual property. These areas need to be addressed if the products developed are to be considered for future production and promotion.

Marketing. Marketing of the final design is an issue and will depend on the size of the organizations involved and who is in the best position to promote the product. Of the three parties the trolley project, the manufacturer and the Architect are likely to be more suited to promoting the product, although it does depend on the situation. For example a book shop chain may be more versed in the promotion of a book trolley than a general engineer who weld up the frames. Whereas an architectural firm may be suited to promoting shop fittings or building claddings.

Another option is to get a marketing or distribution company to promote the product, or alternatively the design could be sold-on or manufactured under licence.

Ownership. Intellectual property rights have to be addressed by all parties involved in the process. This is one of the major issues of integrating product development when several parties are involved, that needs to be addressed.

Obviously it will have to be assessed on a job by job basis, and problems are likely to occur. Problems can arise when the client pays for the development costs as part of the fee and therefore should expect to own all rights. However the manufacturer needs some incentive if they are to become involved early on in the development process, which will in turn give the client and architect an acceptable product. This could include the prospect of a new design, and sole rights to manufacture, as well as tool or design ownership.

The Architectural team must have a role in the design, coordination of resources and planning of the project and therefore require some form of ownership. The development costs increase at an average rate of 45% from phase to phase so all parties need to be aware of these costs if they are to become involved.

To date the architectural profession is not familiar with the general rules of intellectual property for product design which is different from house design rights, and if product development is to become more widespread, a greater understanding of intellectual property issues will have to be addressed by the profession.

To sum up, clearly all parties require a positive return on their time, money and expertise invested, and this is a vital issue that has to be addressed at the start of any development work. It is at this stage when contracts should be drawn up and the services of a patent attorney and solicitors be employed regarding royalty agreements and ownership.

New Zealand context

The furniture manufacturing industry in New Zealand is similar to Italy, in that there are many small family owned and operated companies so there is no reason that the type of work as presented in the Nomos example cannot be undertaken, except for budget restrictions. There are small contract firms, capable of small runs, already servicing the Architectural industry. Some of these firms have high innovation potential, and combined with good old Kiwi know-how and a structured development program with leading architects and designers, they could produce valued-added products for the local and export markets.

The gradual change from primary production into secondary product manufacture offers scope to the architectural industry for the export of products. Export potential may also exist for New Zealand ideas and products to be developed to a stage where the design can be sold to overseas buyers. A form of governmental support already exists with the 20% New Zealand produced quota that is set up to restrict imports, therefore protecting local suppliers rather than reversing it to increase exports.

More support for public works is required, including the selection of New Zealand architects and development projects that would offer the potential for more exportable products. This support should promote the development to produce acceptable architectural environments and to increase the export of value added products in the area of architectural products. This could be in the form of link-up schemes between architectural firms and research bodies.

Possibly it is time that New Zealand Architecture looks forward to become an area where there is an export potential for manufacturers to develop primary products into secondary products for the architectural industry. This already happens with: New Zealand wool exported to Australia and made into carpet; timber becoming furniture; and aluminum turned into metal products, but at present the input from architects, who are usually the specifiers is limited.

Conclusions

There is a failure of many architectural practices to realize the potential in design for sustainable manufacture, and produce one off designs that ideally could be mass produced.

There is a high proportion of R&D involvement in the building process which is redundant after project completion, although it can be accredited to the designers' compilation of design knowledge. It should be used in the development of main-stream products.

There is a lack of user testing procedures in the architectural plan of work. Understanding of the methods used by the multi-discipline teams presented in Chapter Two will inform New Zealand architectural practices of the possibilities for development in the architectural industry.

There is potential for the following to occur within the New Zealand architectural industry.

Observe —› Visualize —› Test —› Evaluate —› Make —› Export Product

Observe —› Visualize —› Test —› Evaluate —› Make —› Export Idea

This development of architectural products and ideas would require support of governmental bodies such as the Business Development Board, BRANZ, and TRADENZ.

Manufacturers need a goal to work towards such as the building deadline for interest to be generated in development projects. The tender situation in public projects poses problems but tendering at beginning of the project will find manufacturers willing to support and be involved in the project.

Recommendation Section

There is a need to change attitudes towards product development of architectural products and to integrate the process into the overall development process of architecture. This includes an understanding of time frames and methods of production, marketing and promotion of the finished products.

Architects need to understand the requirement for end users in testing procedures. The concept development stage of development projects needs expanding to include discussion with users as there is a lack of user involvement procedures and general market feedback in the Architectural Plan of Work. This requires the use of models and the explanation of the overall concept to both the technical and public users.

A multi-discipline approach is required to include professionals who can input to the product development process where Architects do not have the skills or time to undertake total design, development and marketing.

Product Development needs to integrate with the architectural industry so as to assist manufacturers with a strategic tool and so improve and meet the potential of both industries involved.

Encouragement schemes are needed were-by architects and manufacturers can work together developing existing products or target specific areas. A lot of small manufacturers already work with and support the architectural industry. But a more structured approach is required with the formation and upkeep of these relationships so that each party is familiar with each other's working method, to formulate ongoing projects rather than the occasional "one-off" job. These schemes could be similar to the Hard Business Network initiated by TRADENZ and could involve the formation of team building and multi-professional development teams. In an educational context, schools of Architecture and Design can provide the initiative for the understanding and inclusion of The Product Development Process in the Architectural Industry.

Illustration Credits

figure 10 Adapted from Architectural Monographs. (1985). p. 112-113. Richard Rogers + Architects, Frank Russell (ed.) B.C. Cole, and R.E. Rogers (eds.), Academy Editions: London

figure 11 ibid. p. 144.

figure 12 Sparke, P. (1989) *1978-1982, Architecture in Miniature* by Furniture Systems: *from Hille to Renault* 'in' Norman Forter, Foster Associates Buildings and Projects, p.31 & p.41.
Lambot,I. (ed.). Vol 3. 1978-1985. pp. 28-41. Watermark Publications: Hong Kong.

figure 13 ibid. p.41.

figure 14 ibid. p.42 & p.53. Sparke, P. (1989) 'in' *1985 - 1987, Architecture in Miniature: The Tecno System* 'in' Norman Forter, Foster Associates Buildings and Projects, p. 31 & p. 41. Lambot, I. (ed.). Vol 3. 1978-1985. pp42- 61. Watermark Publications: Hong Kong.

figure 15 ibid. p.46, 47.

figure 16 ibid. *adapted from* p.48, 49.

figure 17 ibid. *adapted from* p.52.

figure 18 ibid. p.51.

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Trolley System

for the

Palmerston North Library

Development

for

Athfield Architects Ltd

Natasha Perkins

June 1995

Contents

1.0 General Description

The development and production of a trolley system will be undertaken for Athfield Architects Ltd of Wellington. The trolley system will be used in the Palmerston North City Council library which is due for completion in May 1996.

The system will be comprised of four trolleys; standard, technical, display, and book return, with each trolley being based around the same frame structure. It is envisioned that some of the designs could be utilized by parties outside the library environment, such as book shops and offices.

2.0 Aim

The aim of the project is to design and develop a trolley system for a library environment. The project will utilize a product development process that will allow sustainable manufacture.

3. 0 Objectives

- To design and manufacture a trolley system that has applied consumer and market testing in the development process.
- Design and develop a system to enable sustainable production for the manufacturer of the product.
- Evaluate the potential of the system as a generic product in the market, both local and international.
- Utilize manufacturing methods not available in single job production runs.
- Research of new materials and processes that could be utilized in the production of a trolley system to create an unique product.
- Foster an understanding of the legal issues and property rights.

4.0 Background

The trolley designs will be based on an existing product, produced by Howard Handling Ltd. The trolley was designed by Natasha Perkins while employed by Athfield Architects for the Wellington Public Library in 1991. There was a high proportion of R&D in the process of developing the initial trolley, and there is now an opportunity to extend the range based around this research, to meet the requirements of the library. There is potential in the design for sustainable manufacture and marketing to other libraries and alternative environments where similar operations are performed.

5.0 Deliverables

Design specification for each of the trolleys that make up the system. These specification will include drawings, supporting documentation, and tested prototypes where appropriate.

6.0 The System/Product Range

The trolley system will provide library staff and users with a flexible adaptable system that will be able to meet the requirements of the ever changing environment of the library.

The system at this stage consists of four trolleys based around a basic frame structure.

Standard book trolley
Technical support trolley
Display trolley
Book return trolley

There is a also fifth trolley that will be investigated, which could house photocopiers and the coin change equipment associated with it.

7.0 Product Criteria

General requirements of the trolley system consist of the following:

- Wheel selection must allow free movement
- Provide protection to environment and trolley user
- Meet ergonomic requirement of users
- Minimal need for refurbishment
- Easy adaptation to frame for manufacture

7.1 Standard book trolley

- Primarily used by librarians
- Used to transport books to and from shelves
- For use in new book processing and repair operations

7.2 Technical support trolley

- Provide support for technical equipment -

Television and video
CD Rom

On-line terminals and printers
Public computers

- Provision for power from external source
- Provision for signage
- Meet ergonomic requirements of sitting, standing and disabled users.

7.3 Display trolley

- For use in small living rooms (sections of library split into living areas)
- Top shelf to be for - display, books returned today
- Provision for signage

7.4 Book return trolley

- Basic frame adjusted to take standard bins for collection and movement of returned books

7.5 Photocopier trolley

- Support frame to enable the following to be moved as an unit.
  Photocopier
  Coin change machine
  Coin payment device

8. 0 Procedure and Tasks

The following tasks are to be undertaken:

8.1 Stage One *Briefing:*

Design Brief
Record Keeping
Planning

8.2 Stage Two *Research:*

Information gathering; *Trolley product evaluation, manufacture's.*
Design knowledge compilation; *Previous jobs, ergonomics.*
Product system evaluation; *Wiring, movement, signage, lighting etc.*
Intellectual property rights; *Patents, Licensing, Legal issues related to joint projects*

8.3 Stage Three *Design:*

Working Brief
Conceptual Design
Concept Development -*User tests*
Detailed Design
Embodiment Design
Design for Manufacture -*Specifications*

8.4 Stage Four *Manufacture:*

Tender Process -*If required*
Supervision of Manufacture
Commercialization issues

9.0 Project Timetable

Milestone dates		*Last date*
Stage One	*Briefing*	*29 May*
Stage Two	*Research*	*26 June*
Stage Three	*Design*	*2 October*
Stage Four	*Manufacture*	*on site 10 March*

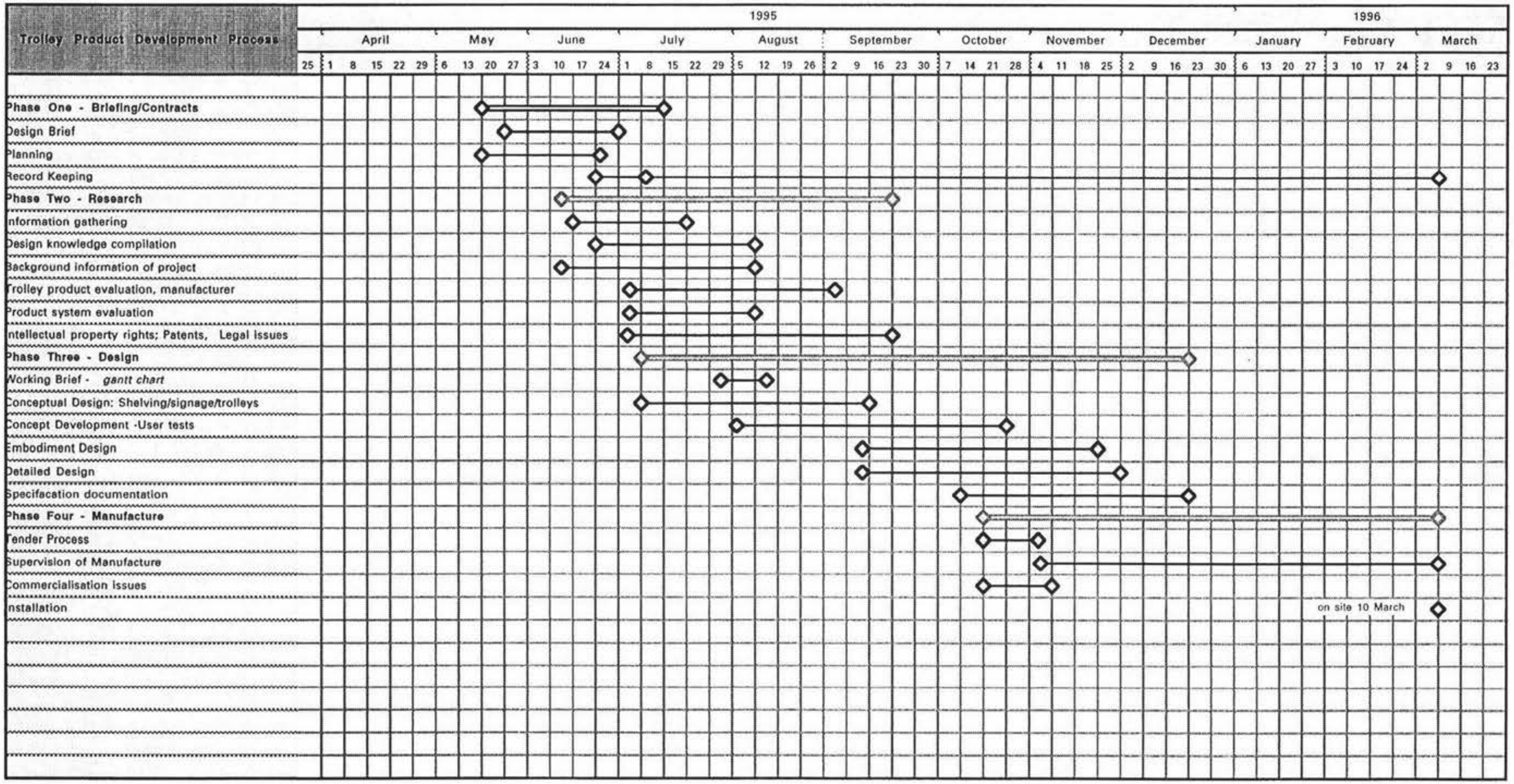
see attached gantt chart

10.0 Project Budget

As yet there is no set budget for this project. The trolleys are part of the overall interior fit-out budget which is due to formulate as other work proceeds.

11.0 Project Team

Anthony Lewis	Head Librarian, PNCC Library, Palmerston North.
Clare Athfield	Athfield Architects Ltd, Wellington.
John Hardwick-smith	Athfield Architects Ltd, Wellington.
Natasha Perkins	Industrial Designer, Palmerston North.
Errol Howard	Howard Handling Ltd, Petone.



Appendix B
Project gantt chart

Standard Book Trolley Feedback Comments

Twelve standard book trolleys were delivered to the P.N.C.C library staff on 28.8.95. for them to use and evaluate in their existing workplace. Below are the comments given to the designer by at a meeting on 21.9.95, four weeks after the delivery and use of the trolley. The comments are copied verbatim from a series of pieces of paper that each staff member expressed their ideas on. The main comments can be summarised as: the need for a central divider; the trolley is too shallow; the preference to height varies; steering - pulling to side; bottom shelf too low; larger and wider wheels for use in the lift .

Please write down your comments about the new trolleys:

Trolleys - the best seen Lorraine.
handle - clearance from books height
easy to push, no negative ?
(central divider - removable)
- height, dividers, rubber surface - Wellington
- Trolleys - Bernie - table, not slip, height, bottom shelf?, top shelf end higher 5cms
- too heavy, good for art i.e. flat surfaces
- Need divider down centre
- Too shallow and heavy - comfy handles though
- Good height for me! Ang.
- Looks good, heavy.
- To shallow, no dividers make life a little tricky
- Really low when loading and unloading, hard on your back. <u>Very Heavy</u>! When pushing out to the shelves/upstairs murder for steering? and on my poor body. (Good drinks trolley)
- Ditto we agree.
- Ditto again
- Smooth
- I like the trolley height, handles, surface, but, steering needs fixing pulls to one side.
- I agree with the above comment. Also found them too heavy and because they slide, my arms and shoulders ached after pushing one for 30 seconds.
- Don't like the handles, and wonder if the rubber surface might crumble apart with use. Found weight and steering satisfactory for me, but won't suit everyone.
- I like them, but suggest a removable partition that could fit in the centre to split each level into two sides for the circ-people to shelve onto
- Interested to see the wear on handles and surface of shelves.
- Great to have enough new ones means there is less squabbling
- Yes, at least you can find a trolley! If you need one
- less overloading
- I like them and prefer taking fancy ends off to lighten. Bottom shelf too low
- Kei te pai nga wakena hou. I would prefer it though if the bottom shelf was not so low
- Keep the fancy ends - they're much easier to grip, I have found, and successfully demonstrated that pushing the trolley widthways is easier. The narrowness prevents people putting <u>too</u> many books on overloading the trolley - which not surprisingly will give them sore back, shoulders etc. Surely the first advice on RSI/OOS consultant would be - make 2 trips with lighter loads. If you look at moving loads of equivalent weight in private light industry - they would not use trolleys! but sack barrows that work on the same principle as lawn mowers/levers etc. of tilt and push. Can you think of any other vocation requiring such regular movement of heavy loads? The surface is great. The handles are lower and easier and don't require the same upper arm movement. The handles are also warmer and rounder and easier to grip and hands.
-If the trolleys steer so badly how will they be with a <u>little</u> wear and tear on the wheels - they need to have longer and wider wheels to make them easier to get into lifts.

Trolleys - Designs and Suggested Numbers 6/11/95 RE

See also attached Design Brief

Introduction

The Technical Trolley and Display Trolley designs were discussed at the Meeting with John Hardwicke-Smith and Natasha Perkins (2/11/95) with a view to deciding how many of each model would be required. Library staff were unable to confirm numbers at this meeting and agreed to furnish Athfield Architects with numbers by Thursday 9th November.

Re-use of existing trolleys, where possible, was suggested in the light of the potential shift of $150,000 from the fit out budget to the Main Contract.

1. Technical Trolley

This trolley was presented as a 'portable workstation' or a position where it was expected that an individual would work at for some time as opposed to OPAC positions which would generally be standing. The development cost of one of these trolleys would be about $1,500.

Television & Video - not suitable, a standard trolley would be sufficient

OPAC's - not suitable, these are designed for longer term rather than casual use and are larger than what is needed for OPAC's

Listening Posts - conventional Listening Posts will be used and the idea of using the Technical trolley design as a Listening Post has been abandoned.

CD-Rom - the Technical trolleys would be ideal for these. 3 CD-Rom positions were identified for Day One

Microfiche / Microfilm - not discussed
Printers - not discussed

Suggested Number 4 - 8 ?

N.B. it was implied that a minimum order of about 6 would be necessary to make the design economically viable.

2. Display Trolleys

These are a modified version of the Standard Trolley with each shelf being able to be converted into a display shelf.
Suggested uses include :

1. **Feature Living Room** (see also 4 - Display within a Living Room)

Clarification of this idea is needed. If a Feature Living Room is intended as a medium term collection e.g. 6 -12 months of 10 - 20 shelves. This is implied by the two commonly used examples i.e. Herbs, and combining the Fiction and Non-Fiction of a particular country. In this example half a dozen of these Display Trolleys would be needed to form each feature Living Room and the top shelf height would be at waist level.

Ext. shelf.

Conclusion - not suitable

2. **General / Public Displays**

For short term displays e.g. Arthritis Week etc . This trolley has some potential because of its portability however it would still need to be supported by conventional Display boards for Posters etc. Also its efficiency is limited because of its height which really only enables the top shelf to be used effectively.

Conclusion - limited potential

3. **Returned Today**

The major issue here is how we intend to deal with Returned Today e.g. by trolley or shelf or both, all collections centralised within a Living Room or each collection having a separate shelf or trolley etc. Using a trolley for Returned Today offers an alternative to conventional shelving and is also very successful when there is a backlog of Shelving / Returns however the Display trolley seems to have little advantage over the Standard Model or the older existing trolleys.
Volume - a standard bay of shelving can provide 8 to 10 shelves whereas in the same space the Display trolley can only provide 6
Height - a standard bay of shelving can provide 4 -6 shelves from waist to shoulder height whereas the Display trolley provides only 2 shelves at waist height. The top shelves are the most widely browsed of the current Returned Today shelves
Fixed vs Variable - the Returned Today shelf is a permanent feature of a Living Room and there is some importance to the public that it be found in the same place for each visit

Conclusion - limited use at best

4. **Display within a Living Room**

Again there is some potential to use the Display Trolley in this way, however there is already a significant amount of purpose built display shelving within each Living Room. Also depending on our shelving philosophy, a proportion of conventional shelving may also be allocated to display within each Living Room. The same arguments as used in 2 & 3 also apply.

Conclusion - limited potential

5. **Magazine Shelving**

Magazines have some specific shelving needs that are reasonably difficult to fulfil with purpose built shelving. Similarly almost all Living Room Magazine collections will be too large to be stored on a single trolley. The same arguments for size apply as in 1 and permanence as in 3.

Conclusion - not suitable

Suggested Number 5 - 10 ?

3. Standard Trolley

This design is generally accepted to have a number of features that are superior to the other currently available models. Specific feedback has been given previously. The major issues influencing the number of trolleys required are ;

a) sorting and shelving procedures
b) how returned today is dealt with
c) budget constraints and the need to re-use existing equipment

Current Book Trolley Numbers (excluding those on Loan from PNL)
New = 11 Existing = 24 Scrap = 4
(Tech Services = 16, Childrens = 6, Collection = 5, Circ = 12 [12noon 6/11/95])

Suggested Numbers

Circulation	20	(includes Newspapers)
Childrens	5	
Fiction	5	
Non-Fiction	10	
Sound & Vision	2	
Youth	2	
NZ	5	
Archives	2	
Technical Services	20	
TOTAL	**71 (less 35 existing)**	

Suggested number = 36 * (new Standard trolleys)

** including Returned Today, Selectors trolleys etc*

MEMORANDUM FROM

Palmerston North Public Library

To : Athfield Architects

From : Stuart Hubbard, Systems Librarian & Steve Holman, Information Systems Consultant

Date : 24 January 1996

Subject : Technology Trolleys

The evaluation of the technology trolleys proposed for the Palmerston North Public Library has yielded the following observations:

Suggested Improvements

1. There is no easy facility to raise the height of a computer monitor above the desktop to improve the ergonomics of the trolley. This is not an issue for short term public use but would be a problem for staff workstations.

2. The keyboard shelf is not deep enough to allow for a wrist wrest or a keyboard wedge in front of the keyboard - a depth of 300mm is needed.

3. The adjustment mechanism for the keyboard shelf was clumsy to use and projected too far downwards. The result is that the mechanism obstructs the knees of taller people.

4. The printer shelf (under the right hand side of the trolley) is not large enough for the printers to be used in the Library. The dimensions of the printers likely to be used with these trolleys are 430mm wide by 350mm deep by 200mm high. A hole for power and printer cables should be provided at the back right hand corner of the shelf.

5. The trolleys moved a little too easily on a smooth surface - a locking mechanism on the trolley wheels would be desirable.

6. The intention of the shelf at the back of the trolley was difficult to ascertain - it is certainly too small for a PC and did not have any other clearly useful function. Is it needed?

7. Varnishing or sealing of the wood surfaces is clearly needed - We believe this is proposed.

8. Some concern about the aluminium flagstaff were raised by some staff - particularly with reference to the possibility of vandalism.

9. The metal document stand has already started to rust - is some coating proposed to prevent this? This feature also seemed prone to theft - has a method of securing this stand been considered?

Good Features

1. The portability of the trolleys is invaluable.

2. The printer shelf could be stowed when not in use.

3. The general style and shape of the trolleys was attractive and is nice change from boring rectangular desks.

4. Although possibly somewhat fragile, the flagstaffs added to the visibility of the trolley

We are looking forward to your responses to these observations. Many thanks for the opportunity to be involved in the design process.

Faithfully

Stuart Hubbard

Feedback and Suggestions

Hello,

This piece of furniture you are looking at is a mobile computer trolley and has been designed for the new Palmerston North Library.

We require feedback from you as a user of this equipment.

Please feel free to write below any comments - good or bad - about the furniture.

Comments .....

To ensure that the feedback to be collated is from a wide range of people, could you please supply some basic information about yourself below:

Male female

Height in centimeters .... or feet/inches ....

In which year you were born ....

Any disabilities that you may have ....
....

How long did you use the equipment for .... hours .... minutes

If you would like to be in a focus group, could you please leave your name and contact details
....
....

Thank you for your time - Please put your comments in the box provided.