

## **FUSE Demonstrator Document No. 27612**

### **“Microelectronic Control of Integrated Showers”**

#### ***“Microcontroller opens US Luxury Shower Market”***

##### **Abstract**

Daryl Industries Ltd, based in Wallasey in North West England, design, manufacture and sell luxury market shower related products, including the showers, pipes and associated control devices, cubicles and cabinets. Daryl has manufactured shower systems for over 30 years and recently introduced an integrated mechanical water delivery system. The company, with 170 employees, has its background in mechanical design and development, skilled in designing water flow and temperature controls and water distribution systems, but has no microelectronic experience. The company's 1998 annual turnover was 18 MEur with the company's growth being 15-30% p.a. over the past few years. The company's customers have been predominantly end-users, with recent growth in sales to larger customers such as hotels and building contractors. The products are sold world-wide, with particular success in UK, Australia and Taiwan. The Industry Sector is Electric Domestic Appliances: 2971 in the NACE classification, which is widely recognised within the EU.

The product to be improved is a purely mechanically controlled shower system (3 brass taps to control hot, cold and flow,) combined with an elaborate brass flow-diverter that allows head selection, temperature regulation and flow control. This product had major limitations owing to the inflexibility of the device components e.g. the control knob had to be near the relevant brass valve body location. The control methods for temperature and flow are very efficient but the water delivery is limited by the complex brass diverter system, allowing only dual-head use at best. With the maximum potential of the existing product being reached there is no way to push further into more lucrative markets (eg U.S.A). The need is for a state-of-the-art, cost effective product with a technology based lead to provide increased functionality to capture sales in the more diverse luxury markets.

The new product is microcontroller based and exploits the advantage of modular design and manufacture, by offering a wide range of systems with various head configurations and positions, built-in safety features and versatile personal pre-sets to allow one button control to access a previously stored shower setting. The microcontroller design uses CAN-Bus architecture to allow this modularity, requiring only two wires to each control and sensor unit.

The added values achieved by using microelectronics are:

- Elimination of costly brass diverters, (with inherent manufacturing problems)
- Maximum flexibility relating to position of controls relative to solenoid controlled valves,
- Simple construction, easier assembly (plumbing) and easier operation (using pre-sets),
- Flexible in-house control and upgrading (additional showerheads incorporated),
- Modularity allows customisation using CAN bus architecture.
- Increased sales are anticipated as a result of the flexibility and customisation.

The project started in June 1998 taking 8 months to achieve a fully functioning and tested prototype at a cost of 58 KEur. The payback period is estimated to be 13 months and the return on investment is estimated to be more than 9345 % over the 3 year life of the product.

##### **Keywords and Signature**

Keywords: Shower, Water flow control, Solenoid valves, CAN Bus, Modular design, Simple Controller, Microcontroller, Environment, Temperature control, Sensor.

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## 1 COMPANY NAME AND ADDRESS

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## 2 COMPANY SIZE

The company turnover is 18 MEur with 15-30% growth p.a. over the last few years. The total number of employees is 170, non of the company staff has any expertise in electronics.

The Product Manager and Designer were both personally involved in the details of the project.

## 3 COMPANY BUSINESS DESCRIPTION

Daryl is a family owned business, which was established in 1966, when the owner saw the opportunity to import patio doors and shower enclosures into the UK from Miami. This quickly flourished into a manufacturing business making the aluminium and glass products in the UK to the US designs.

The technical excellence of these products was their main strength with little or no competition the mail order sales of Patio doors provided the funding of the business today. By 1976 the market was far more developed and the need to establish competitive products to fight foreign imports was of prime importance. The patio door market had been lost to direct selling and the decision was taken to re-establish Daryl as the market leader for shower enclosures specifically directing the marketing towards the top end of the market. This meant designs had to be innovative, well engineered and the marketing of the Daryl brand took on greater importance.

The company was successful in achieving its aims and then looked to move into other areas relating to the shower environment and vacuum formed acrylic shower trays were launched, followed by the award winning water delivery system Hydrasenta.

This was a considerable achievement, as Daryl had no background in this area and had to use consultants to provide the expertise to educate the design team in the requirements of this type of product. Skills relating to plumbing, brass casting techniques and CNC machining of aluminium were all developed and the Design & Development Department are able to create new products for this market without the use of consultants. We are particularly proud of a patent for a diverter, which uses a ceramic disc system manufactured for us in France.

The company carries out all the associated activities of design, development, production and marketing from a single site based at Wallasey on Merseyside, UK. The company has R&D, fabrication, assembly and sales and marketing departments on this site.

Daryl has no experience in the use of microelectronics for the design or manufacture of their current range of products. This range contains no electronics but as described above we do have considerable design experience in shower related products. Over the last 30 years an extensive range of bath screens, shower enclosures, doors and trays have been designed, developed and marketed in the UK. The Company is actively increasing its market share in world markets and continuously introduces new products.

### Industrial Sector

The Industry Sector is 2971: Electric Domestic Appliances in the NACE classification used throughout the EU.

## 4 COMPANY MARKETS AND COMPETITIVE POSITION

Daryl Industries product range currently is based around water delivery systems and shower enclosures with the ability to provide a complete shower-unit ready for installation. Our extensive use of extruded aluminium has also led the company to manufacture ladders and patio doors in the past, but now we specialise solely in the shower market place.

The existing market for products in the luxury customised shower sector is 49.3 MEur for Europe and we presently only have a small share of the UK market of 406 KEur. A typical cost for a complete electronic control system for an integrated shower is about 600Eur, this does not include the cubicle, assembly and installation costs.

In this market Daryl is noted for its ability to deal with large corporate customers, building suppliers providing customised integrated showers for new homes and hotels and have appointed agents for foreign sales. Other target customers include Cruise ships, Sports Centres, Hospitals and Prisons. Daryl has a reputation for products of quality and reliability.

There is large potential for this type of product with continuing growth in our existing business providing the platform for us to increase turnover on an annual basis by at least 15-30%. Our shower enclosure designs have always concentrated on the top end of the market where the desire for innovative products can command substantial premiums.

This project has the potential to unlock areas of the European and American markets that we have had difficulty entering and experience has shown that a unique design is the best key to these new markets. Electronic showers in the American market have "Jacuzzi" as the biggest existing supplier of the product and all available electronic showers use variations on the touch panel theme as the user interface. After considerable market research, we realised that there was a market for a more sophisticated shower that utilised the conventional shower control interface with the benefits of electronic control.

The existing Hydrasenta shower product average cost is shown in the table as 290 Eur.

The market for the existing product is shown in the table below:

Current Product	1997	1998	1999
Turnover current product (KEur)	249	300	406
Cost current product (KEur)	125	150	203
Profit current product (KEur)	125	150	203
Number of current products sold	430	520	700
World market share current product	0.1%	0.12%	0.16%

Competitors will already be aware of the current product but are unlikely to realise the impact this flexible design will have on the world market. One of the key features of the flexibility is the ability to sell this in many different countries with the opportunity to customise the product to the particular installation/technical requirements and user needs of the area.

On the basis of the anticipated growth of Daryl in America, Australia and Taiwan a market will be established for the product and 1.5% share of the world market would seem a realistic aim over the product 3-year life by 2003-2004.

The step we have taken uses the true potential of microelectronics to provide control, sensing and a far more sophisticated interface with the user (much improved on the cluttered touch panel of existing designs). This is achieved with no increase in price. To our knowledge none of our competitors currently using electronic controls in the delivery of water in the shower environment have identified the possibility of using technology in this way. They only use electronics to provide touch panel controls and attach this to the existing brass taps.

The present market in the UK is served by of the following companies: -

- Caradon Mira (part of Stelrad Group) - mechanical controls
- Aqualisa - mechanical controls
- Newteam - now introducing basic electronic versions
- Ideal Standard and Armitage buy in products and systems
- H. Grohe - world leaders in both mechanical and electronic showers, valves and equipment.

This is not a price sensitive part of the market and as such the competitors are always concentrating on new innovative features to sell their new products.

The main competitor, Hans Grohe has regularly produced high quality expensive, top end products with a very successful product range. The challenge is to design a product that is perceived as equal to their products but with a user-friendlier interface, modular and with a customised memory. All other manufacturers are trying to fight in the middle market where large retailers are forcing prices down. All the competitor products rely on membrane touch-pads to select temperature control and flow-rates to interface to the electronics behind and we wanted to differentiate our product from the rest of the field. The idea behind this logic was to give it mass-appeal, from the very young to the very old, without the user even being aware of (or put off from) the controlling mechanism behind the scenes. The goal was to directly compete with the market leader on a technology level, and to supersede on an aesthetics front.

We are aware that the luxury end shower market has several electronic control systems that will be able to offer the several simultaneous spray-heads option that our prototype will do. However we do believe that our product will be the most flexible (easily adaptable to any layout requirement) from its modular implementation and CAN Bus Interconnectivity. We will also be able to compete directly (on both cost and spec.) with the market leading H. Grohe product and believe that our product will have the most appealing user-control-interface.

The Industry Sector is 2971: Electric Domestic Appliances in the (EU) NACE classification

## 5 THE PRODUCT TO BE IMPROVED and INDUSTRIAL SECTORS

The current product is the Hydrasenta shower, described as the 'total showering experience'. It is compact, discrete, versatile and ergonomically designed to maximise usability for people of all ages.

The attached photographs show the enclosure and a representative diverter valve assembly, indicating that the bulky brass diverter valve and solenoids determine the dimensions of the shower column of the existing product.

Hydrasenta combines many features designed to optimise personal choice with the following features:

- Fits neatly into a corner,
- Multiple shower options with 2 heads,
- Sprays to the cubicle centre away from the door,
- May be turned on before entering the shower,
- Fail-safe thermostat and safety stop button,
- Hydrasenta is quick and easy to install.
- Temperature 0-70C, flow 0-16 litres/min.



Typical Hydrasenta Shower Cubicle

The existing Hydrasenta range of showers use entirely mechanical open loop control by the operator to set the temperature via a thermostat and a rotary knob for flow.

The product to be improved has established Daryl in the water delivery market but does not (apart from the patented diverter) have any of the innovation that customers expect from Daryl products. We have produced a quality product designed not to stretch us too far in fear of the new technology and our dependence on consultants.

This existing product is deficient on several counts: -

- The design is limited to one option of 5 different spray combinations and cannot be customised,
- The lack of customisation limits the marketing and the design and manufacturing,
- The brass valve technology is directly linked to the control knobs and comparatively bulky (15cms x 6cms),
- The cost of the product, when integrated into a shower-enclosure, is higher than some of the instantaneous-water-heater systems available. These have a small electronic element and can provide features such as indicator lights. These are appreciated by the customer and seen as features to be provided on expensive products.
- The lack of flexibility with the existing brass diverter means that the water flow has always been quite restricted with severe spatial constraints and difficult to assemble. The diverter utilises a two-part machine-finish high quality brass moulding with a precision ceramic disk sandwiched in between. One water inlet supply coming into the unit is then diverted through the watertight sealed disc's orifice to one of the four desired outlets to the required showerhead. High manufacturing costs and the inherent quality assurance problems of trying to maintain fine (watertight) tolerances meant that it would be desirable to replace this diverter in the new product. An additional limitation with this complex brass moulding was that it limited the number of simultaneous showerheads to only two. The company realised that to break into new markets in the U.S. they would need to be much more flexible, with American market research indicating that 4- 5 sprays working at once was a desirable feature.
- All of the above limit the possibilities for future products and it was agreed that a new quite radical approach would be needed to create the same response for water delivery as we currently have for our enclosure. We intend to be with the market leaders but this product does not provide us with the necessary framework to build on.

The proposed improvements arose out of a basic need to maintain a lead over possible competitors and in simple terms, include the following features:

- The mechanical system is to be replaced by **electronic control** with multi-point controls at correct positions for able/less able users,
- The concept of **modularity** using the same electronics for each sensed and controlled element with added flexibility and pre-set control for individual personal repeatability,
- To establish a **consistent rotational stiffness** for each of the 3 control knobs.

The concept is to have a multi-layered control system with electronic user interface suited to specific needs.



**Brass Valves and Diverter  
Assembly**

The improvements to be made to the existing Hydrasenta can be summarised as follows:

- The mechanical system is replaced by electronic control of multiple heads,
- Modularity, flexibility and enhanced performance is introduced,
- Pre-set control for individual repeatability is now provided,
- The cost of manufacture is reduced.

## 6 DESCRIPTION OF THE TECHNICAL PRODUCT IMPROVEMENTS

The project is to design an electronic control system capable of replacing the three manually operated controls of the current Hydrasenta with computer software driven motors and solenoid valves to regulate the flow and temperature.

The new product is shown in the picture and the PCB assembly within the shower assembly indicates the placement and modularity.

The previously used diverter system has been replaced with a control valve close to every showerhead outlet. This eliminates the expensive brass diverter, with its inherent costly manufacturing to close tolerances and the quality assurance problems previously encountered with having to fully test every unit before assembly. This improvement means easier assembly for plumbing and PCBs within the simpler, cheaper column control housing. Electronic operation meant that the previous 'central-lump' control space limitation is eliminated as the modular system could be spread out throughout the column length of the sealed unit. This removes the need for costly moulded chrome-plated plastic covers that concealed the brassware.

Maximum flexibility is obtained by freeing up component positioning, especially relating to the position of the user controls relative to solenoid controlled temperature and flow valves.

Simple user interfaces were enabled using piezo switch control buttons close to the shower head for each head operation, and in the central console for the personal pre-set selectors. The pre-sets are the main added customer feature to the improved product. These can be individually customised to previous flows and temperatures for repeatability.



**Shower Unit showing control column**



**PCB Assembly in shower control column**

The user can now set up a pre-set shower configuration by using the hand controls to set the flow and temperature desired and then a long press on one of the four pre-set buttons memorises the unique combination and recreates it every time that specific pre-set button is selected.

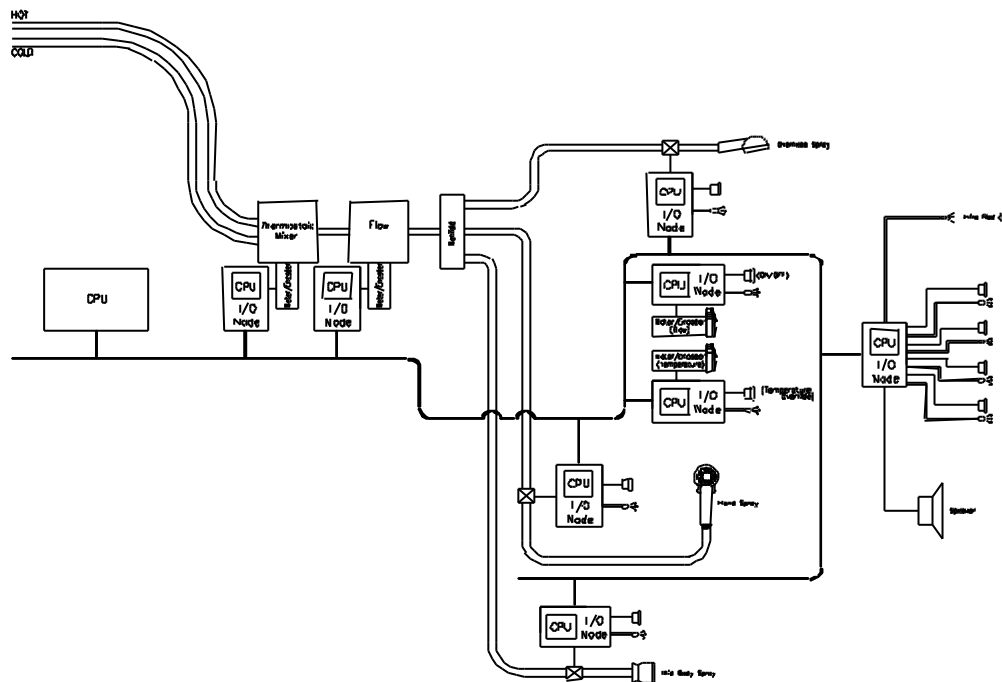
The modularity of design allows for easier incremental upgrade and customisation (Plug 'n' Play type system construction easily offers more control units via the 'CAN-bus' communication connections). From the product's advantage of modularisation, the microcontroller communication utilises a CAN-Bus to enable all separate PCBs (each with its own micro on board) to talk to the main controller and allows additional showerheads to be added to the system by simply tapping into the CAN-bus. Each board is simply incorporated into the system via the PCB pin-out configurations, rather than having to modify the software, and can hence customise any specific individual system easily.

The proposed improvement summarised earlier arose out of a basic need to maintain a lead over competitors and in simple terms, includes the following features:

- Multi point controls at correct positions for able/less able users,
- Modularity implements the same electronics for each sensed and controlled element,
- Identical rotational stiffness for each of the 3 control knobs,

The concept is to have a multi-layer control system with electronic user interface suited to the specific needs of:

- Elderly family member or guest- Electronics provides facility to have consistent safe start.
- Parents / children - Each family member has a pre-set to simplify operation.



2W Solenoid Valve  
CANBUS + Power Supply

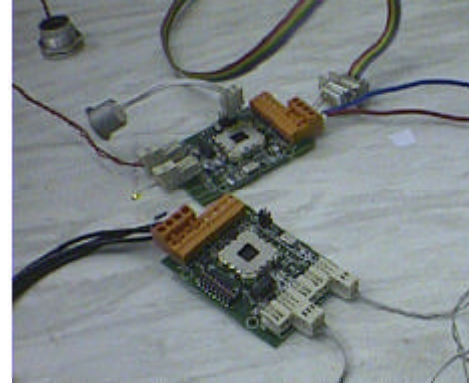
**Shower Architecture**  
(CAN BUS shown interconnecting CPU & I/O cards)

The new design architecture is shown in the diagram and comprises the following components:

**Microcontroller.**

The Siemens microcontroller was selected for the following reasons

- Available with a built in CAN controller.
- Available at reasonable cost.
- Low cost development starter kit available.
- Support from Hitex company who have Siemens / CAN track record.



**Prototype PCB Assembly**

**CAN-bus**

The CAN bus was selected over other communications options such as I<sup>2</sup>C and RS485 due to:

- Designed for simple two-wire operation as high speed multi-master bus,
- Well-defined standard with noise immunity and address resolution mechanisms.

**Piezo switches**

The piezo switches were chosen to meet aesthetic needs of the product. Any type of push button switch could perform the task. With no moving parts, artwork or artificial relief could cover the piezo to achieve the desired look and feel.

**Plug and Play**

This concept was designed to allow various show models to be assembled with software re-configuration. The approach reduces redundancy for small systems and allows large systems to be produced by simply adding more modules. Each module is identical and hence the spare part inventory is reduced. Faultfinding is simplified as the module which is connected to the element, which is not functioning, may be replaced independently. Software design and debug is also reduced to the design of a one-channel device with networking.

The old parts had several disadvantages – they were costly, unreliable from a supplier point of view with heavy costs for checking quality, bulky to store and difficult to make modular. The new electronic version is still costly but order quantities can be quite small, the electronics industry is geared up to quality measured in ppm, they are compact to store (lighter too) and most importantly lend themselves to assembly in a modular format.

The main parameter that has been improved, and of immediate interest, is the functionality, with the overall product cost remaining similar.

A comparison of the customer sensitive application between the old and new product is shown below:

<b>OLD WATER DELIVERY SYSTEM</b>	<b>NEW WATER DELIVERY SYSTEM</b>
Stiff mixer and flow taps with course control	Easier to operate fine control with consistent feel
No pre-set option with trial and error temperature selection	4 pre set options (more if customised) with previous used settings easily selectable.
Thermostatic valve	Same valve but finer control resolution
Poor and restrictive flow due to constrictions of divertor	No divertor so better flow with more heads available
Mechanical temperature override	Press button system easier and more reliable

Comparison of Old and New System Costs (for a typical system):

<b>OLD TAP &amp; DIVERTOR SYSTEM</b>	<b>NEW MICROCONTROLLER SYSTEM</b>
Assembly cost 60 Eur.	Assembly cost 30 Eur.
Component cost 230 Eur	Component cost 260 Eur
<b>Total cost 290 Eur</b>	<b>Total cost 290 Eur</b>

The market sector that Daryl operate in is more interested in exclusivity and innovation than cost saving.

Reliability is important to Daryl customers and we offer a lifetime guarantee, heavy emphasis has been placed on the selection of suppliers and components that can achieve this goal. The testing already carried out and that which we have planned for the future will ensure that we able to offer this to our customer.

The simple operation of the wide range of features combined with a reliable operating system will set this product apart from its competitors.

The technologies implemented in the new product use a microcontroller and the CAN bus standard.

Research for all Daryl products has shown a consistent requirement by the consumer for ease of operation and a major difference between this product and its direct competitors is the attention paid to the user interface being friendly.

In this particular instance where we are introducing new technology it was important to strike a balance between the need to let the consumer know that the product has many electronic features and at the same time not present these in a confusing or daunting way.

We feel we have achieved this balance by making the 2 main controls familiar in appearance and function but hidden behind them is the electronics, giving us the ability to achieve so many more additional benefits that customers have requested.

The final prototype consisted of a fully working prototype shower system where the individual heads and control modules can now be separately mounted at various locations around a shower cabinet and connected only by water pipes and the 2 wire control bus.

The initial number of production units is expected to be modest, rising to 6000 by the second year. For this reason a modular approach has been adopted providing both the actuator and sensor systems. The unit cost of the individual actuator/sensor component is estimated at 50 Eur.

The full shower assembly consists of several heads, each using a modular actuator/sensor component.

These features represent improvements relative to the competition.

## **7 CHOICES AND RATIONALE FOR SELECTED TECHNOLOGIES**

Initially the project required choices to be made on the basis of the technical expertise required to implement the product.

Daryl Industries did not have any electronic expertise but knew the market requirements.

### **TECHNOLOGY**

Technology choice was made from the initial feasibility study and discussions with subcontractors.

The volumes to be used, the complexity of the control algorithms and the need to vary them from product to product along with the requirement for a user defined design, clearly influenced the choice of technology. We require to customise the design at low cost. The typical volume is expected to be initially less than 1000 p.a. rising to 6000 p.a. by the second year.

ASICs require large numbers to justify the non-recurring engineering cost and are inflexible components for a product that requires customising. They are regarded as a high-risk route to pursue with an associated large technology step for the first time user of Microelectronics.

FPGAs and MCMs were both considered to be components that would, technically, provide a solution but would not give the required flexibility for customising and future development without high

additional costs. The unit costs were again considered to be high when the NREs were taken into account.

ASICs, FPGAs and MCMs are not easily adaptable to the anticipated changes needed for customer special requirements typical of the market sector served by these products. Additionally, we were advised that they may be too large an initial technology step for a company with no electronic expertise.

We require an easily adaptable technology with a short learning curve that can easily be understood by a First User with little or no microelectronics background. For these reasons Daryl chose the low cost CMOS microcontroller technology.

The Siemens micro controller was selected for the following reasons:

- It was available with a built in CAN controller.
- It was available at reasonable cost.
- A low cost, development-kit was available.
- Support was available from a company who have a Siemens / CAN design track record.

A Siemens SAB-C505CA-5EM chip was chosen with a One-Time-Programmability (OTP), a CAN controller, an A-D converter. Both the price and availability were good. The software program was written in a mix of 'C' and assembly language to make the best use of the limited chip resources.

### **Can-bus**

The CAN bus was selected over other communications options such as I<sup>2</sup>C and RS485 because:

- It is designed for simple two-wire operation as a high-speed multi-master bus, (ideal for the arrangement and positioning possibilities available for shower configuration individuality.)
- It is a matured, proven (over 10 years), and well-defined standard designed to operate in a harsh environment with good noise immunity and error handling.
- The selected subcontractor had considerable experience using the CAN Bus.
- Tried and tested development tools are available.

Daryl Industries made these choices on advice received from our subcontractors.

## **METHODOLOGY**

During development of the AE a solution to the problem of how to ensure that the operation of the product was simple to perform and easy to understand.

It was found that trying to build a flow chart, on paper, showing the sequence and variation of operations was almost impossible and the decision was made to find an alternative methodology. At this stage of a non-electronic product design we would normally go to a working mock-up to test ergonomics and gain new user feedback but this is not easy when looking at the sequence of operations controlled by the software.

The decision was made to use Visual Basic to programme the basis of the operations and link this to provide a computer visualisation of the user controls. We were then able to work out our initial ideas and more importantly start to involve people who had no idea how the system worked and were able to "trip it up" in ways we had not envisaged. This was a great help and a part of the operation that at first had seemed unmanageable was now within our control and gave us instant feedback with almost instant modification to the programme. The Visual Basic programme was used to run a dry working prototype for testing the real user interface rather than the computer visualisation. This was used as the simple layout for the C++ programming which merely needed translation from its first draft form.

Fabrication Technology: - Due to the modest production quantities required, a conventional glass fibre PCB with through-hole components was used. Components were chosen for reliability with ease of procurement and assembly, placed ahead of cost.

The development process followed the established pattern of Daryl and its sub-contractors forming a partnership to ensure that the technology is fully understood.

A structured top down approach was used to establish a clear brief/functional/technical specification to meet the users requirements.

Fabrication, Test and System evaluation methods were developed concurrently with the detailing of the technical specification. The development process currently employed by Daryl, uses Multi-discipline teams to ensure all interested parties have input to the technical specification.

## TOOLS

The tools requirement for the project needed (a) visualisation design assistance to develop and evaluate the customer requirements, and (b) the microelectronic design phase needed to implement code to use with the selected Siemens CMOS Microcontroller. The microelectronic design was subcontracted to DEVA whose experience determined the tools used.

To implement the basic control functionality and design on a Personal Computer, Visual Basic was adopted (described earlier).

The subcontractor, DEVA, was responsible for the design process, this involved taking the functional specification and creating an agreed technical specification, this then was used to implement the required microcontroller software.

DEVA used the programming language 'C' to implement the Siemens CMOS microcontroller design.

The tools used were 'C' high level language together with the Siemens Development suite and in-circuit emulator (ICE) using the SK-505 starter kit with 32 kByte SRAM and 128 kByte FLASH memory and supporting the CAN Bus and RS-232. All the controller signals and ports are accessible at the pin connector so that the circuit operation and the functional diagnosis could be easily implemented.

**Test Methods:** - Alternative hardware and software designs were evaluated and the CAN bus system selected was then developed, tried and tested using an interface card linked to a PC with custom designed test systems to check the links between the actuators and sensors.

The prototype was fully tested against a clearly defined set of benchmarks and finally incorporated into a full working prototype (including enclosure and human interface designs) using the in-circuit emulator before the flash programming of a stand alone microcontroller device.

**System Evaluation:** - All manufacturing methods for the electronics were fully evaluated by Daryl and testing carried out for RFI, EMC and CE marking.

**Documentation:** - On successful completion of the system evaluation, the final documentation package comprised the final revisions of the following:

System Design Specification,  
Design Notes, Software Listings, Electrical Schematics, Electronic Schematics,  
PCB Artworks, Parts Lists,  
System performance data and comparative results data.

It was a condition of the contract with Deva that all documentation be fully integrated into the Daryl D & D systems.

## 8 EXPERTISE AND EXPERIENCE AND STAFF

Daryl Industries experience and expertise was limited to the design, manufacture and marketing of an integrated mechanical shower system.

Daryl needed to acquire the design skills for microelectronics to enhance the performance of our products, reduce the manufacturing costs, increase the volume of sales and increase profits and have the ability to apply microelectronics to many more products in the future.

Daryl staff had no experience in the design or specification of electronic components required during the project such as: -

- Electric/electronic motors - Sensors - User Keypad (or other Interface)
- The technical specification of products such as CMOS microcontrollers,
- Skills to test and evaluate the results to achieve and ensure the product is the best,

Daryl needed to build the confidence of the Design & Development department and also the company as a whole in use of electronics. We were at the bottom of the learning curve and would not be able to undertake a project such as this without considerable support.

**Designer** Existing departmental skills: To aid the design process, currently using several CAD packages, including Autocad R13, Autocad'LT and 3D Modelling. He has been involved in many process-related designs, such as CNC programming, AutoLISP, Pascal and PLC programming but has no experience in Microelectronics.

**Product Manager** The product manager has been a designer with Daryl for 22 years and been involved in a key role in the design department. Involvement in other areas has provided experience as Purchasing Manager, Anodising Plant Manager and Q A Manager. As product manager key achievements have been to establish Daryl as one of the most innovative manufacturers in our industry with award winning designs, e.g. Liverpool Design Initiative Award for Best Product Design but has no experience in Microelectronics.

## 9 WORKPLAN AND RATIONALE

The rationale behind the original project plan assumed that Daryl did not intend to design the Microelectronics components, and was based on the following key activities which formed the basis of the project tasks.

**A preliminary investigation** was undertaken by Daryl Industries to determine the performance and user friendliness of the existing product, which was accurately evaluated, so that key parameters for the design of the new controller could be established. Evaluation of the sensors used to monitor the water flow and temperature were investigated in detail.

- **Management** of the project was the responsibility of the first user. Monthly meetings and reports by the First User and the subcontractor were generated on a monthly basis as the project implementation continued through planning, specification, design and evaluation. This ensured that control of the costs and the schedule was maintained.

The planning, management and reporting were as scheduled and within cost. The subcontractor contributed to the planning of the design phase and the cost was 1.5 KEur.

- **Specification** of the product was the responsibility of the first user, the Daryl design engineer and the subcontractor used sensor and control data compiled in the preliminary investigation phase to write the functional specification.

The subcontractor engineers checked and suggested amendments to this specification, which was developed into a detailed technical specification by the subcontractor and approved by

the first user. This phase took longer than expected, was completed very satisfactorily the subcontractor cost being 8.5KEur over a period of 2/3 months.

- **Training** in the use of new tools for the first user was delivered by the subcontractors.

Training involved four different modules:

- Introduction to the Management and Specification Microelectronic projects –1day

- Introduction to ‘C’ programming – 3 days

Both courses were provided by Bolton Institute, the first was provided as planned early in the project, the second was implemented towards the end of the project.

- A Visual Basic training course was provided by DEVA immediately following the specification phase.

- Design for Microcontrollers was provided by DEVA and consisted of a hands-on understanding of the application of programming, the cost of this was subsumed in the design budget.

- **Design of the microcontroller prototype** was the responsibility of the subcontractor, DEVA, and included the initial prototype testing.

The first prototype was assembled, tested and completed within a period of 4-5 months from July to November 1998 as indicated on the Gantt Chart.

The subcontractor costs were 18.24 KEur.

The first user working in close co-operation with the subcontractor, obtaining hands-on experience of the technical work necessary accomplished the knowledge-transfer.

The previously planned course ‘Design for Microcontrollers’ was implemented during the design phase of the project.

The Daryl contribution to the design is recorded as a total of 20 days.

2 days employed in assisting with system design, 8 days assisting with software design & simulation, including the equivalent of 2 persons for 3 days (6-days) for the ‘Design for Microcontrollers’ hands-on course.

Prototype production used 6 days compared to the 2 planned days and the software design simulation a further 4 days compared to the 2 days planned. Visual Basic was used to model the control system and check the software design routines up to and including the prototype production work, Daryl needed to be re-assured of the right aesthetics, as well as the functionality for the product. This was a crucial part of the prototype development, and we wanted to be sure that the control interface felt and looked right. The subcontractors design costs were higher than planned due to the Microcontrollers training course subsumed.

All the necessary documentation to support, maintain and improve the design was satisfactorily passed from the subcontractor to Daryl. At the "Managing Micros" training-course the importance of company's maintaining the IPR for the new development work was impressed upon the company.

The subcontractor owns the design and it is strongly advised that other company's intending to replicate should follow formal contract terms.

- **Evaluation & Testing** of the prototype was the responsibility of Daryl Industries with the microelectronic prototype being completed by Deva.

The test rig construction and assembly was completed by Daryl and the subsequent functional testing was undertaken by Daryl using test schedules written by Daryl.

Assistance was needed from DEVA in this phase of the programme. This stage was the responsibility of the first user. The evaluation was completed by Daryl in February 1999.

The following workplan indicates the original schedule and compares the planned and actual days spent on the project and the subcontractor costs.

**The Transfer of Knowledge** throughout the project was successfully implemented by:

- Learning the software packages and design tools in the training and design stages through direct hands-on contact with the subcontractor,
- Microcontroller concepts were introduced to the First User during the Specification of the new product and specifically applied to produce an advanced design during the design stage,
- Working closely with subcontractor throughout the design stage,
- Evaluation assistance from subcontractor in the testing of the known product and the new microcontroller implementation,
- Documentation produced by the subcontractor detailing the design and programming language statements employed.

Daryl Industries Ltd		Planned Days		Actual Days	
		Daryl Ind Ltd	Subcontr. Costs KEur	Daryl Ind Ltd	Subcontr. Costs KEur
<b>4.1.1 Management</b>					
	Plan. Manage	9		12	
	Report	9		6	
	<b>Total</b>	<b>18</b>	<b>1.815</b>	<b>18</b>	<b>1.5</b>
<b>4.1.2 Specification</b>					
	Functional	2		4	
	System	2		6	
	Technical	2		12	
	<b>Total</b>	<b>6</b>	<b>4.25</b>	<b>22</b>	<b>8.5</b>
<b>4.1.3 Training</b>					
	Management & Specification	2		2	
	Intro to 'C' Programming	6		6	
	Visual Basic	6		6	
	Design for Microcontrollers	6		0	
	<b>Total</b>	<b>20</b>	<b>6.3</b>	<b>14</b>	<b>3.15</b>
<b>4.1.4 Design</b>					
	System Design	2		2	
	Software & Hardware Design	2		8	
	Prototype Production	2		6	
	Software Design & Simulation	2		4	
	<b>Total</b>	<b>8</b>	<b>13.175</b>	<b>20</b>	<b>18.24</b>
<b>4.1.5 Evaluation</b>					
	Prototype Production	2			
	Test Rig	2		3	
	Functional Test	2		5	
	Prototype Test	2		5	
	Full Test to Design Spec	22		15	
	<b>Total</b>	<b>30</b>	<b>7.245</b>	<b>28</b>	<b>4.32</b>
<b>First User Total Effort</b>		<b>82</b>		<b>102</b>	
<b>Subcontractor Effort (Costs KEur)</b>			<b>32.785</b>		<b>35.71</b>

The above Workplan indicates the additional effort, expressed as costs by the subcontractor and time of Daryl, taken to produce a detailed, clear and agreed specification. This incurred a delay before the start of the design phase. The delay caused concern at the time, but later proved to be the right decision. The extra time taken here resulted in the following phases of the project running smoothly and as seen on the Gantt Chart kept close to the planned time.

The Gantt chart shows the original baseline plan and actual outcome.

The main areas where the first user, Daryl, made the greatest impact were those not directly related to the electronics such as:

- The initial concept brief,
- The project timeplan and management,
- The control of meetings and documentation,
- Methods of sourcing new suppliers (emphasis was not just to use the current base of knowledge of our subcontractors but quickly enhance both companies awareness by visiting trade shows),
- The use of Visual Basic as a design tool for software,
- 3D visualisation (using Visual Basic) to remove the “fuzzy front end” of software writing,
- Linking the electronics to the external components and in turn the customer.

Early in the development we were aware of the need for a software design tool. It was decided that Visual Basic software would provide a good tool for quickly modelling the structure of the programme and would provide the type of flexible framework needed to change the model.

It is similar to the way 3D modelling is used for injection moulding designs.

It also interfaces with the 3D visualising software which permits demonstration of the way the human interface works without the user being daunted by the visual impression of a standard computer interface.

An important element of this project was to check early decisions regarding the way the user operates the product. This emphasised the deficiencies of current products on the market.

Extra time has been taken to make sure the basics are right!

The possibilities afforded to us by using electronics were actually a handicap when it came to making decisions. It is useful to note that this would be a key area of work following the product launch.

Clarification of the functional specification was enhanced by the flexibility afforded by the use of Visual Basic and the training given by Deva. The programme was modified while the design team discussed the options and then using the on screen buttons and the link to the motor controls the solution was verified.

The technical specification was still not complete and this is definitely an area where mid project changes to the timeplan were necessary. We were confident that this would not substantially delay the completion of the project as we believed that the time and effort taken to ensure the detail was correct in the early stages would pay big dividends when we came to the latter stages.

We slowed down near to the last third of the project while a final decision on the purchase of components was considered. A problem to us was:

- Should we be constructing a prototype or a pre-production model
- A pre-production model would allow a quicker progress to the next phase.

Exhibitions were visited and feedback obtained on competitive products. A visit to Electronica helped confirm the decisions made. In the final stages of the project good progress was made with the benefit of feedback following the exhibition.

The last few weeks of the project saw major developments with specifications coming together and detail being finalised. The first fully operational prototype (running in visual basic on a PC) was presented to the main board of directors. At last, the reluctant mechanical-believers were being converted to the benefits of microelectronics.

## **DEVIATIONS**

The functional, technical and test specification phase took longer than anticipated, the cost was higher, and there was a delayed start to the design phase, these are shown in the Gantt Chart below. At the time it caused some concern but was justified later with the smooth running of the project.

The subcontractors training budget is now lower than planned. The basic skills already within the company proved a good foundation, resulting in a shorter learning curve.

As the project proceeded we were able to recoup some of the time lost in the specification phase and was one of the more important lessons learned and messages to be conveyed to other users - “the specification should be correct” at all costs.

A delay in the progress of the design phase at the point of testing was due to subcontractor staff leave during the summer. This was a consequence of the subcontractors limited design staff.

ID	Task Name	Start Date	Duration	1998				1999
				Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1
1	Planning	01/06/98	20d					
2	Actual	01/06/98	20d					
3	Reporting	01/06/98	150d					
4	Actual	01/06/98	180d					
5	Functional Specification	01/06/98	20d					
6	Actual	13/06/98	12d					
7	System Specification	01/07/98	15d					
8	Actual	01/07/98	22d					
9	Technical Specification	01/08/98	4d					
10	Actual	01/08/98	4d					
11	Management Micro Training	01/06/98	1d					
12	Actual	29/06/98	1d					
13	Visual Basic Training	01/07/98	3d					
14	Actual	10/08/98	3d					
15	Programming Micros Training	03/08/98	3d					
16	Actual	30/11/98	3d					
17	Micros Design Training	01/09/98	3d					
18	Actual	15/12/98	3d					
19	System Design	01/08/98	7d					
20	Actual	20/08/98	7d					
21	Hardware Design	12/08/98	8d					
22	Actual	31/08/98	8d					
23	Software Design	03/08/98	20d					
24	Actual	07/09/98	20d					
25	Prototype System & Testing	01/09/98	20d					
26	Actual	10/11/98	20d					
27	Test Rig Evaluation	01/10/98	4d					
28	Actual	09/12/98	4d					
29	Produce Working Prototype	02/10/98	2d					
30	Actual	15/12/98	2d					
31	Test Prototype	01/11/98	30d					
32	Actual	17/12/98	30d					

## SUBCONTRACTOR INTERACTIONS

Interaction was consistently employed during the project to maintain, monitor and control events:

Progress review meetings were held on a regular monthly basis and involved the first user, the subcontractor and the TTN. Progress was monitored, reports written and contingency plans actioned when necessary. e.g. the specification phase extended to produce a clear product specification at the expense of time delay. Also, the training and use of Visual Basic introduced to help design and visualise the final product in a form suitable for customer use and evaluation.

The main areas where the subcontractors made the greatest impact were as follows: -

- Driving through a detailed specification for both software and hardware,
- Programming experience that only comes with a wide variety of different projects being completed successfully,

- PCB design (specialist software was used),
- Building of mock-up using motor drivers to operate controls,
- Building and testing of first off prototype,
- Testing of prototype and debugging programme.

## 10 Subcontractor Information

The requirements of the project indicated the need for a subcontractor who had the skills and experience in microelectronics appropriate to Microcontrollers, CAN Bus and 'C' programming and who we could have the confidence would advise us correctly. There was also a need to provide training and it would help considerably if the subcontractor had a good track record and was local.

**Deva Electronics** is an electronic design consultancy which supplies a range of innovative products and design services to a client list that includes manufacturing companies, research groups, service organisations, system integrators and OEMs.

Deva were a company with staff qualified in the areas required and with an ability to explain a difficult subject in simple terms. They were a good fit with Daryl and were local.

Deva Electronics has 4 staff, 3 of whom are engaged in electronic engineering products and projects. Annual turnover is approximately 200 KEur of which 20 - 30% is generated from product sales.

Experience covers a wide range of languages such as 68HC11/68000/80x86 assembler and 'C'/'C++'. Recent work has involved updating the company's motion control products to take advantage of current ASIC technologies and the design of a low power radio transmitter to DTI specifications.

In the past, Daryl had made a point of establishing the IPR for all product development work prior to embarking on such a project. Having done this type of work before, the subcontractor was reluctant to relinquish IPR in this instance. The First User was not put off using them, as the subcontractor, as they were only interested in the knowledge transfer and prototype development. No formal written legal contract was entered into between DARYL Industries Ltd and the subcontractor. However, all the work was satisfactorily completed on a professional basis with standard terms and conditions agreed as part of the normal purchasing agreements.

All the payments and deliverables were satisfactorily completed on a professional basis with standard terms and conditions agreed as part of the normal purchasing agreements.

The subcontractor owns the design.

**Bolton Institute Technology** Development Unit is part of the Institute of Higher Education and was set up to develop Microelectronics Applications support for industrial research, development and technology transfer. The unit, which was formed in 1992, is currently managing in excess of 3 million Eur of research and development contracts mostly in UK.

The unit provides access to specialised training and able to manage projects from the feasibility stage through to the design and prototype stage. Bolton Institute TDU provided support for the Application Experiment.

- ***The role of Bolton Institute***, as subcontractor to this project, has been to provide advice and training in the use of the programming language 'C' with particular emphasis on 'Good Design Practice'.

Both of the subcontractors provided the agreed and required service when needed without management interaction and this short project completed in 8 months. Monitoring meetings allowed the project to be controlled with advice from the TTN.

## 11 BARRIERS

The lack of previous experience of electronics was crucial to the way in which the project was approached. The concept had been shelved at several New Product Development meetings due to lack of confidence in our ability to produce results.

The concept of the product was clear but how the result could be achieved very unclear.

Daryl has in the past been faced with the need to develop technologies, which were new to the company, there was therefore a degree of awareness regarding risks and testing.

Daryl Industries Ltd had no experience in the design and specification of electronic components, motors, sensors, and microcontrollers. Experience was limited to mechanical design and the use of mechanical application programmes e.g. Autocad..

**The Technical Risk** was that we were so inexperienced in the use of electronics that the potential for making a wrong decision was great.

The company identified the need for assistance in training and technical support. It was important to develop a partnership relationship with our subcontractors, both companies are local to Daryl and this has become a feature of the way we have worked together.

With no support or advice Daryl could have adopted an incorrect or inappropriate technology.

**Cultural, Inertia and Financial Barrier** - The company is owned by an engineer, and the MD is from a financial background so the fact that we are a very market lead company creates a very balanced view on new product development.

We did however in this case come across the feeling of “should we be making an electronic version of the existing product when we know nothing about electronics?”

**The Commercial Risk** is primarily the damage that could be done to the reputation of the business as a direct consequence of the technical risks.

The economic benefits are directly related to the new skills that Daryl has acquired. Daryl had a steady growth in their existing business (approx 15-30% per annum) and knew they had the ability to deliver the product to the market. They were unsure of the move into electronics especially with water being involved and they were unsure about moving into an area of expertise they did not have. The decision to go ahead was made on the basis of a good plan and a drive to stay number-one in a growing market. This was the right time to develop the product.

## 12 STEPS TAKEN TO OVERCOME BARRIERS

Daryl took the following steps to overcome the perceived and actual barriers to this new development outlined in the previous section:

As we progressed through the minefield of a development area in which we had no previous experience we were assisted by the subcontractors, Bolton TTN and Deva, who guided rather than dictated the route we should adopt!

Employing and establishing a close working partnership with our selected subcontractors and seeking advice from the TTN whenever needed overcame the **Technical risks**. A significant help came from the need to be continuously monitored by the TTN. The monthly monitoring meetings and discussions were conducted in an advisory capacity and were invaluable technically and managerially. Decisions were made

FUSE provided the ability to apply an appropriate new technology in a virtually risk free manner, with highly skilled support, both from the subcontractor, TTN and potential suppliers of components and services. The message is “ don’t try to it on your own!”

The subcontractors employed through the FUSE project have facilitated the introduction and training in this new area and have increased the technical knowledge base considerably.

**The Commercial Risk** outlined was partially overcome by our successful FUSE application and provided the ability to apply an appropriate new technology in a virtually risk free manner, with highly skilled support, both from the TTN and potential suppliers of components and services.

The choice of subcontractors was vital to the success of the project and we were pleased to find Bolton and Deva more than adequately met our requirements.

The subcontractors employed and the training in this new area and have increased the pace of change with a far lower commercial risk to the company.

**The Initial Cultural Barriers** will always be present in advanced (to us) projects of an essentially new nature and we overcame these with help from both the subcontractors. It is important to state that there is a volume of goodwill ready to be tapped – ask and help will be forthcoming.

The assistance from FUSE helped lessen the risk in the minds of the board with the result that we have an almost evangelical conversion to the idea of the electronic product and that this will become a key part of the future product range.

### 13 KNOWLEDGE AND EXPERIENCE ACQUIRED

Daryl Industries have acquired more microelectronic knowledge and experience than initially expected. They will continue to employ expertise in future microelectronic design projects but now have sufficient experience to manage projects in this area.

- Daryl management, which already had project management skills acquired in the industrial process control sector, has extended these skills to the management of microelectronic development projects.
- A network of suppliers of expertise in project management, specification, design, testing and assembly of microelectronic products has been established for use in future projects.
- Daryl technical staff has benefited from the technical training given under the FUSE programme, they now understand the technology incorporated in the new product and are capable of implementing testing, installation set-up and faultfinding. They do not have the technical knowledge to implement microelectronic design but can customise the product.
- Daryl management have gained confidence in the application of microelectronics, in particular:
  - There is a greater appreciation of the benefits of using microelectronics.
  - A more imaginative perception of the potential for new products due to the power and flexibility of microelectronic devices.
  - The use of microelectronics is now a key component in planning new products.

Skill	Prior to AE	After AE
Microelectronic Design Skills	None	Limited, but a good understanding of Design Practice
Ability to apply design skills to future products	None	Yes
Production of microcontroller specifications	None	Yes
Microcontroller testing skills	None	Yes
Microcontroller product evaluation skills	None	Yes
Evaluation of microelectronic competitor products	None	Yes, but assistance may be required

## 14 LESSONS LEARNED

This completed project provided the required and necessary product and we have obtained a specific solution in addition to the introduction of DARYL Industries Ltd to new technology and general company advancement in business.

The following lessons have been learned, which are not specific to the project, but which are written as advice to future companies intending to replicate.

- The lack of experience in setting schedules for this type of electronic project is obviously the cause of miscalculation. These proved to be time consuming in the early stages, because so many of the components were inter-related and could not be specified at an early stage. The additional time taken in the specification phase paid dividends later with very few problems occurring in the latter stages of the project. The message is “Get the specification right”. Even if it seems to be taking too long it is foolhardy to proceed without doing this properly.
- The specification of components was dependant on getting up to speed with what is available and being new to the industry and wishing to get involved in the detail of the project we did not wish to just hand this over to our subcontractor (Deva). The need to speed up the process of gaining industry knowledge was satisfied by some timely exhibitions in London (ECIF), Bologna (Cersaie shower related) and Dusseldorf (Electronica)
- Visual Basic was used as a design tool to simulate the product. Daryl design staff used this software to introduce design features and subsequently test the model for correct operation and for conflicts. The use of Visual Basic is recommended where appropriate to the project. Training requirements to accommodate Visual Basic and C+ were included. The use of Visual Basic saved a considerable amount of time resulting in an easy transfer of software requirements into C+.
- The real-time changes that were made during the investigation of the functional elements of the design were only made possible through the use of the simulation of the product in a visualisation package (3D Studio) and linking this to the Visual Basic programme. It resulted in a virtual product we could test on people not directly involved in the project.

## 15 RESULTING PRODUCT, INDUSTRIALISATION AND REPLICATON

**The outcome of the project** has been a state of the art product reflecting very closely the original concept and will provide a wide market potential. It has met the product specification and will provide a product line extension to the existing company business having met the target cost.

A summary of the new shower design:

- The prototype is operating as predicted. All the basic functions have been achieved and within the cost target. Users are able to understand the controls without an instruction manual and are unaware of the electronic sophistication but still have the “joy” factor when pre-sets turn the controls to their individual setting.
- Assembly is simple and provides the framework to easily customise future products.
- Safety issues that were addressed as part of the specification have been maintained by using simple, non-moving (easy clean) components at the user interface. Reduced voltage is also an industry standard that we have been able to adopt to reassure potential purchasers.

- A simple “black box” construction with only hot and cold water connections and standard 24 volt transformer wired into normal housing circuits means fool proof installation.
- An upgrade for the next generation has been designed and the system will easily accommodate the inclusion of infra red remote control for more sophisticated user programming.
- Other products have been initiated which are designed to incorporate electronics of a similar nature and now form part of a Smart Award for innovation. These control, using electronics, the pattern of the spray in a new spray-head design without moving parts.
- This AE has created a basic building block for a customised water delivery system. The way in which the functions are replicated from controller to actuator and from function to function provides the means and flexibility needed for the 5 year planned growth of Daryl.

**Industrialisation of the prototype** has been investigated and the budget set at 60 KEur with the early models to the market by the end of 1999. Industrialisation involves:

1. Mechanical enclosure redesign, tooling and assembly development. Components testing and PCB assembly of components and testing procedures.
2. Setting up a special build and test area. Staff and facilities for both the mechanical and electronic assemblies will be needed including the development and training of staff.
3. Other facilities are to be incorporated into existing stock holding, documentation and shipping methods are necessary to support the product.
4. Product approval procedures will be addressed as on-going tasks.
5. Initial launch to UK Platinum partners market scheduled for March 2000
6. Field testing will be continued through the initial launch to full launch date scheduled for August 2000 with incremental designs included where appropriate and beneficial.

The electronic Hydrasenta is being researched with consumers and retailers at present and the results will be presented later. The indications are that the product will be launched along with a number of variations of the existing shower enclosures and new accessories.

It is anticipated that some incremental redesign will be necessary following further consumer research and the initial launch with consumer feedback through the Platinum accounts.

The electronic Hydrasenta is an integral part of the strategy for future product development at Daryl.

The concept of a flexible electronic design that can be adapted to a wide variety of configurations is the only way to succeed. Customer’s expectations are increasing at a fast rate, especially when making buying decisions for expensive domestic products.

**The initial launch** will be as an exclusive product for the Platinum accounts of Daryl in March 2000. These accounts are partners with Daryl and although their numbers are small (less than 200) they provide 40% of our current turnover. They need exclusive products and understand the concept of the system and provide important early feedback from our installers and end users.

**A full launch** is planned for August 2000 when we expect volume sales.

**Marketing the product** will emphasise the versatility of the product with initial options available at the time of launch representing the starting point of a generation of similar products.

Replication will include plans to include electronics into spray head designs styled around the concept of spray head. The next generation will be remotely controlled and programmed followed by bath versions which will have the ability to not only provide a shower over a bath (especially important where space is restricted) but they will also be timed to fill the bath to a set level and temperature.

The development of Daryl's New Product Concepts has embraced the use of electronics and will be proposing a steady growth in the number of products within our range that use electronics. It is an integral part of many kitchen appliances and experience has shown that bathrooms follow a similar market trend.

The success and use of microelectronics has meant that projects designs previously rejected due to the need for electronics are now included in the future plans of the Design and Development Department.

One specific example is a new showerhead. This will use a unique method to create the spray form that reduces the amount of water needed and result in a high performance shower with low water usage and thus lower cost (not only to the consumer but also the environment!)

<b>Industrialisation Schedule</b>	
FUSE project start, feasibility, specification, hardware and software design.	June 1998
Completion of FUSE project and prototype build, test and evaluate.	February 1999
Completion of production prototype. 'Final' design and emc approval.	December 1999
Mechanical enclosure redesign, tooling and assembly development. Components testing. PCB assembly, etc. Build and Test area development of staff, procedures and training. Assemble trial batch and first production quantities. Product approval. Initial launch to UK Platinum partners market.	March 2000
Field testing and incremental redesign. First batch available for shipping. Full formal launch.	August 2000

## **16 ECONOMIC IMPACT AND IMPROVEMENT IN COMPETITIVE POSITION**

The new product is produced at the same cost as the existing product. It is controlled electronically using microcontrollers. It has improved functionality, with flow and temperature control to the multiple heads and is modular. It is user friendly with the provision of customised settings.

We predict, by market research conducted during the project, that these features will considerably increase our market share.

Daryl intends to replace the existing mechanical version of the Hydrasenta with the electronic version in existing markets as soon as it is available. The mechanical version may possibly be used to open further new markets where a less sophisticated product would still be appropriate.

The American market currently, has electronic controlled showers. Jacuzzi is the biggest existing supplier of the product and all available electronic showers use a touch panel as the user interface, none of which are easy to comprehend as a user. Daryl believes that in addition to incorporating electronics it is essential to develop a well designed user interface.

The following table summarises past, present and forecast sales of the complete specialised shower units in the UK. The predicted effect of the new microcontroller launch is shown for the period 2000 to 2003. The figures do not include the additional sales as a result of marketing efforts into other new market countries, etc.

Note: Not all the products are the same price, nor have the same degree of functionality, complexity or user options. The actual and projected sales are made up of a mixture of different product models and the mix may change from year to year.

Justifications for the increased sales of the new product include:

- Entry into extensive new markets in USA where customised fashion products with a high specification are required in volume (marketing/agents feedback verified),
- A high technical specification featuring 4 heads and 5 showering options that fit neatly into a corner. Safety features include fail-safe thermostat and safety stop button. Hydrasenta is quick and easy to install. Individually customised with specific person pre-select.
- The product is easier to use and has automatic energy-saving features. (It has always been Daryl's belief that the basic operation modes must not be 'too space-age' nor too removed from conventional operation)

<b>Current product</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>
Turnover current product (KEur)	300	406	580			
Cost current product (KEur)	150	203	290			
Profit current product (KEur)	150	203	290			
Number of current products sold	520	700	1000			
World market share current product	0.12%	0.16%	0.21%			
<b>Improved product</b>						
Turnover improved product (KEur)			116	3750	4500	5200
Cost improved product (KEur)			58	1875	2250	2600
Profit improved product (KEur)			58	1875	2250	2600
Number of improved products sold			200	6400	7600	8700
World market share improved product			0.04%	1.25%	1.36%	1.49%

The table shown below is taken from previous product trends and expected sales figures, assuming a growth of 15-30%, without innovation, through years 2001-2003, an estimated profit of 1305 KEur would result over the 3 year life of the product.

<b>Current Product</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>
Turnover current product (KEur)	406	580	696	870	1044
Cost current product (KEur)	203	290	348	435	522
Profit current product (KEur)	203	290	348	435	522
Number of current products sold	700	1000	1200	1500	1800
World market share current product	0.16%	0.21%	0.23%	0.26%	0.30%

The introduction of the new product, which will allow expansion into new European and World-wide markets, and associated increase in sales result in an anticipated increased profit of 5420 KEur over the 3 years 2001-2003. The anticipated market share is shown below.

The table indicates that the anticipated increased profit resulting from the introduction of the new product (and Fuse investment of 58 Keur) will give an ROI of 9345% over the expected 3 year life of the product.

The payback period is estimated as 13 months.

Estimates of the target market are based upon entry into new European and World-wide markets via established agent networks and these opportunities are summarised as follows:

<b>Summary of Target Market (KEur)</b>				
	<b>UK</b>	<b>Europe</b>	<b>World</b>	<b>Total</b>
<b>Market Value</b>	4200	49300	250,000	
<b>Present Share</b>	406	-	-	
<b>Target at 2001</b>	2012	988	750	<b><u>3750</u></b>

## **17 ADDED VALUE TO THE PORTFOLIO AND TARGET AUDIENCE**

### **Target Audience**

Daryl Industries Ltd, based in Wallasey, UK, have been manufacturing shower systems for over 30 years, they employ 170 staff and have no electronic expertise. This document is targeted at other SMEs in the electro-mechanical field marketing through OEMs who will be looking to update their products with the use of microelectronics.

The target audiences for FUSE information are SME's with products that do not use electronic components for the luxury domestic and semi-professional markets.

- Specifically small companies with no electronic expertise who are predominantly mechanical manufacturing establishments who use electrical components as part of their product, e.g. lamps, switches, motors with their associated interconnection wiring.
- Small companies addressing custom markets.
- Companies needing subcontractor expertise to implement microcontroller designs.

The target industry sectors are therefore:

**Industrial Sector:** Electric Domestic Appliances; Prodcom Code: 2971

The target areas for replication are those companies with no electronics expertise producing products using mechanical equipment where new technology employing microelectronics and innovative user friendly facilities are required to maintain or increase sales in a highly competitive luxury domestic and semi-professional market.

### **Summary of Best Practice**

This application experiment illustrates the best practice benefits of developing a detailed, documented and clear product specification, and the benefits of using Visual Basic as a tool for the clear design, development and evaluation of a user friendly mechanical component based on microcontroller device technology.

The application experiment also disseminates best practice based on the experience of the company in selecting and employing a suitable subcontractor, conducting regular meetings with a detached organisation such as a Technology Transfer Node, and the importance of staff training, project planning, monitoring and reporting.