FUSE Demonstrator Document No. 1403

"A Gas Controlled Incubator"

"Sales up 20% using a Microcontroller"

Abstract

Ruskinn Technology was established in 1994 and has 7 employees with 1 Electronics Engineer and 3 technicians. They are now market leaders in the design, manufacture and marketing of Gas Controlled Incubators for the Microbiology Industry with a focus on the Far East, particularly Japan. The team has in excess of 40 years marketing, mechanical and basic electronic engineering experience. Products are sold through exclusive local agents, country by country. Annual sales are 400 KEur.

Gas Controlled Incubator Workstations are a specialist product used to isolate anaerobic organisms quickly, reliably and cost effectively. The company operate within this single specialist area. The Incubators are manufactured in-house.

The existing design monitors and controls temperature, pressure, relative humidity and the gas content of the two chambers of the incubator. The system uses a Programmable Logic Controller and relays for the control and display of gas pressure, operational sequences, status and warnings. The PLC is a significant component expense of the current design of enclosure and price increases by the manufacturer have made the current product much less competitive in export markets.

The new design is modular and designed around two separate microcontrollers, one provides the friendly user interface/operator I/O and the other provides the incubator monitoring and control functions at a total cost saving of about 50%. Temperature is controlled to 0.1% and humidity in the range 40-90%. Sequence control is provided for commissioning cycles, sample placing and removal in addition to chamber gas control. The new technology has been designed and developed and implemented using subcontractor skills and expertise. Ruskinn Technology staff with microelectronic experience are now able to manufacture, service, maintain, test and evaluate the product in-house.

The project started in May 1996, took 17 months and cost 52KEur. The estimated payback period of this investment is within 2 years with a three-fold ROI over the life of the product.

Keywords and Signature

Keywords: Control, Simple controller, Environment, Controller, Biological, Medical, Temperature, Humidity, Gas

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1 COMPANY NAME and ADDRESS

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2 COMPANY SIZE

The Company has a total of 7 employees comprising:
The Managing Director a Marketing Executive and a Mechanical Engineer,
One Electronics Engineer and 3 Technicians.
The Company turnover was 400KEuros in 1997.

3 COMPANY BUSINESS DESCRIPTION

Industrial Sector:	Machinery	Code: 29
Product Code:	Non Domestic Cooling and Ventilating Equipment	Code: 2923

Ruskinn Technology was established in 1994 and has 7 employees. It is now a market leader in the design, manufacture and marketing of Gas Controlled Incubators for the Microbiology Industry with a focus on the Far East, particularly Japan.

Ruskinn Technology expertise is in applied microbiology systems specifically in the field of equipment used for anaerobic culture growths under laboratory conditions. Gas Controlled Incubator Workstations are a specialist product used to isolate anaerobic organisms quickly, reliably and cost effectively.

The company operate within this single specialist area and have design, manufacturing, product test capabilities and market/sales expertise.

Ruskinn Technology, who manufacture their product in-house, have designed and developed the product from a close relationship with the customer base through the sales and marketing activity. The new technology designed product has been developed and implemented using subcontractor skills and expertise.

The product base is now being expanded from the single comprehensive ‘Concept’ product to a range of products that meet the varying budgets of a wider customer base using the new technology.

4 COMPANY MARKETS and COMPETITIVE POSITION

Ruskinn Technology products are purchased by the microbiology and biotechnology industry. Work with anaerobes is in its infancy and growth rates are potentially good. The distribution of sales is shown in the table.

MARKET	% OF TOTAL TURNOVER 1997
Asia	38%
EC	33%
USA	21%
Africa	8%

The company is well positioned to become a market leader as the market takes off. Sales in 1996 were 383 KEur increasing to 566 KEur in 1997 and 687 KEur in 1998.

The market is international with current products being sold in 14 countries outside the EC.

All products comply with the strictest European standards e.g. IEC 1010.
The company's goal is to be market leader and produce an EC manufactured product that is world class.

Currently the brand is No. 1 by market share in Japan, Korea, Taiwan, Hong Kong, Singapore and No. 3 in the USA. The current Application Experiment will help us maintain this position and improve our share in other markets especially against the four large US based companies who are considered our major competitors. Since all our products are sold via exclusive local agents, country by country, we also see spin-off "motivation" that benefits in sharing with these vital business partners the message that Ruskinn products are continuously developing and that the company has a commitment to being a brand leader.

Projected quantitative impact of the Application Experiment

	1995	1996	1997	1998
Turnover current product	325K	383K		
Cost current product	6250	6500		
Profit current product	35%	33%		
Number of current products sold	52	59		
Market share current product	17%	20%		
Turnover improved product			560K	730K
Cost improved product			6200	6125
Profit improved product			40%	40%
Number of improved products sold			90	110
Market share improved product			30%	37%

5 THE PRODUCT TO BE IMPROVED and INDUSTRIAL SECTORS

The existing design is based on a Programmable Logic Controller which is a significant component expense of the current design of enclosure. Price increases by the PLC manufacturer have made the current product less competitive in export markets.

The current design is limited in its ability to incorporate interactive control of the oxygen content of the incubator. This has been identified as a market opportunity not satisfied by current products.

The main features of the Concept Plus Anaerobic Incubator, shown opposite, are:

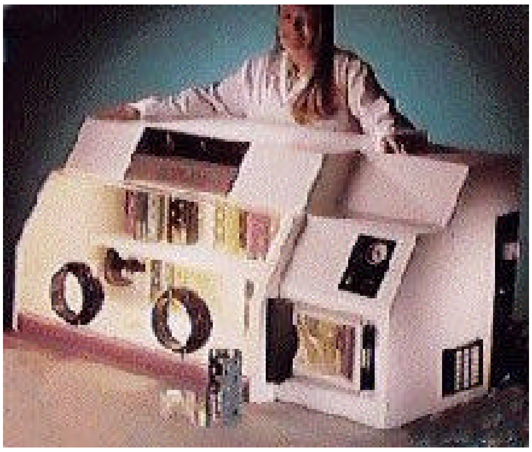


Figure 1

- The incubator must maintain a positive gas pressure of the anaerobic gases to ensure that no oxygen enters the incubating chamber.
- Two types of gas are used to keep the chamber oxygen free (anaerobic), nitrogen and the anaerobic gas. Because the cost of these gases is high, especially the anaerobic gas, usage must be monitored to minimise wastage.
- Gas supply lines from the gas bottles are monitored to ensure that gases do not run out without providing adequate warning to users.
- Ensure that the chamber in the anaerobic state is not opened to the atmosphere, and oxygen contamination. An interlock chamber is needed to allow loading/unloading of specimen dishes.

- A sequence of operations ensures that the inner and outer doors of the interlock cannot be opened simultaneously. When in the loading sequence the vacuum pump evacuates the chamber before being purged with nitrogen and brought to the correct pressure with the anaerobic gas.
- Time exposure of granule packs, for the removal of oxygen residues and toxic by-products, is monitored and warning messages given to indicate that service is required. A similar process is used to predict service intervals for the fans providing forced circulation.
- Temperature within the chamber is to be maintained to within to +/- 0.1 degrees over a range of 30 to 40 degrees Celsius.
- Relative humidity of the gas in the chamber is maintained to +/- 1% from 40% to 90% RH.
- The Concept Plus has the facility to connect a satellite chamber to the main chamber. Additional temperature, humidity, etc. monitoring and control is required for this chamber.
- Foot switches are provided to allow the operator/user to have a hands free operation for turning lights on/off, gas on/off, and vacuum on/off for front port glove operations when manipulating specimen dishes.
- Control of Internal lights and Internal power.
- Facility for recording the performance of the system.
- Display system for gas pressures, operational sequences, status, warnings, etc.
- There is a large cable harness and manufacture of the microelectronics is labour intensive.

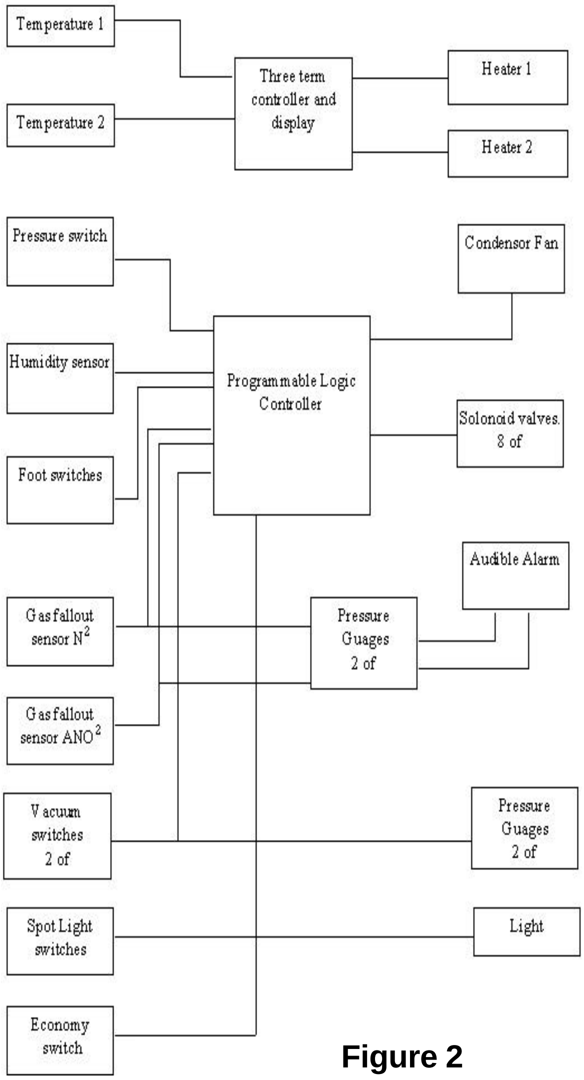


Figure 2
Block Diagram of Existing Design

The cost of the existing system using a Programmable Logic Controller, 3 term temperature controller, discrete displays, analogue gas pressure meters, vacuum meter, gas valves and discrete components for display and monitoring is 1,160 Eur.

6 DESCRIPTION OF THE TECHNICAL PRODUCT IMPROVEMENTS

The new design shown in Figures 3/4 indicate that the system is designed using 2 microcontroller boards. The functionality of the system is such that one contains the user interface and the other is used to monitor the system parameters and the control sequences required for safe operation.

The system is modular and has enhanced capability and functionality over the existing design. This will lead to its application throughout the whole range of anaerobic incubators currently in production.

The lower cost products are a more simple and less sophisticated system design available at lower cost and can be used in conjunction with the new design of main control board.

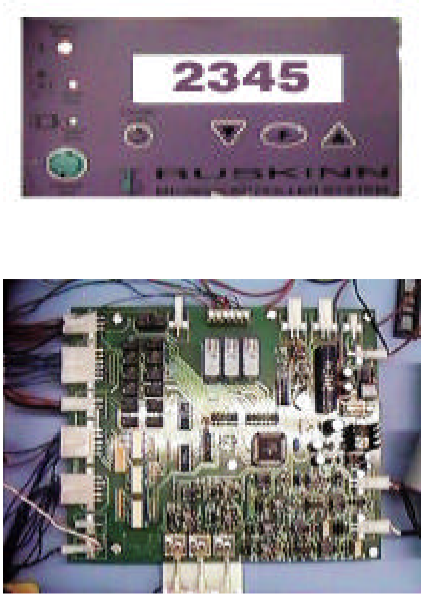


Figure 3
Circuit Board and Control Panel

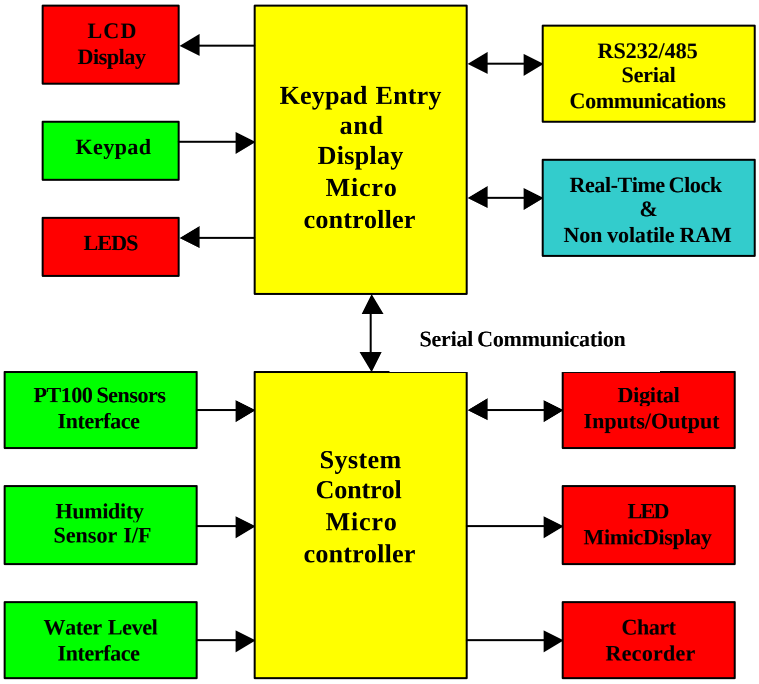


Figure 4
Block Diagram of New Design

The Functional Specification of the new product incorporates all the features of the existing system and provides for product evolution, lower cost and greater flexibility.

The main features of the microcontroller based monitor and control system implementation are to:

- Monitor and control the temperature of both the main and slave chambers to a predetermined operator set temperature in the range 30/45 degrees C with a tolerance of +/-0.1 deg. C,
- Monitor and control the chamber humidity in the range 40-90%,
- Monitor the chamber atmosphere for oxygen content,
- Monitor and control the system gas flow to ensure correct operating conditions,
- Provide sequence control for :
    - Commissioning cycles,
    - Placing and removing samples,
    - Chamber Gas Control,
    - Measure gas supplies with alarms.

The generation of the specification took more time than expected.

Ruskinn Technology recommend that any company undertaking a new, to them, technology should seek clear advice and opinion on this essential aspect of specification before commencing the project. Getting it wrong can delay progress and cost more money than planned.

Ruskinn are enthusiastic about the technology and appreciate the dilemma of supporting current production whilst trying to incorporate and reap the advantages of the new technology.

It was essential for the subcontractor during the design, to train and assist Ruskinn Engineers in the new Technology. Without the support and expertise of the subcontractor in all workpackages, the project would not have been possible.

Continued expansion of the core business has highlighted the necessity to recruit a graduate Electronics Engineer to work in close association with the subcontractor. Also for Ruskinn to ensure that the lessons learned during the experiment and the benefits of incorporating microcontroller technology into the existing product range are realised in the short term.

7 CHOICES AND RATIONALE FOR SELECTED TECHNOLOGIES

Design Methodology

It was necessary for the functional/technical specification developed by Ruskinn Technology with the assistance of the Bolton Institute TDU to provide the following features:

- The system was required to be modular, in order to be used in a range of anaerobic workstations manufactured by Ruskinn Technology.
- The requirement needed 3 term Proportional, Integral and Differential (PID) control which would be tuned to different sizes of anaerobic chambers, i.e. different volumes of gases to be controlled, different temperature sets points for the main and satellite chambers.
- Relative Humidity needed to be measured and controlled.
- The use of simpler and cheaper instrumentation for gas monitoring and control was to be an option.
- An increased range of operator/user operational parameters should be included in the design.
- A user friendly graphics display interface to provide information.
- Monitor and record running times, gas usage and maintenance to predict service intervals,
- Provide a variety of data logging outputs, i.e. chart recorder, RS232, 4-20 millamp interface,
- Ability to adapt the monitor, control, user interface display and data storage algorithms throughout the product life.
- The ability for the company to provide field service upgrades to the system at reasonable costs.
- To enable the software to be developed for the evolving ranges and capabilities of the anaerobic workstations.
- Relatively low production numbers, 100 to 200 units per year are required.

Analogue interfaces were designed to interface to the PT100 temperature sensors, gas pressure sensors, etc. This was necessary to pass the signals to the microcontroller for conversion into digital signals for processing by the microcontroller.

The component will be tested in house and Ruskinn Technology will incorporate the microcontroller into the Concept range of anaerobic workstations to check that anaerobic conditions are produced and maintained and the correct level of system control is attained.

Fabrication Technology

By discussion with subcontractors the forgoing requirements indicated that an FPGA, ASIC solution would not be flexible enough for the system needs. The relatively low number of products required per year indicated that the associated NREs and the high amortised development costs would be excessive.

It was decided that the most appropriate technology to use was a CMOS microcontroller.

Investigations into the costs associated with the microcontroller chips, development tools (In-Circuit Emulator) for the microcontrollers and the availability of high level programming languages were carried out.
The Arizona Microchip PIC16C74 device was selected as being the most appropriate microcontroller system with which to design the new system.

The product is manufactured/assemled and tested in house. Printed circuit boards are produced by a subcontractor but assembled and tested in house. Initial software development was implemented by the subcontractor, but support for the new and planned products will be in-house.

Tools

The technology based tools requirements for the project were to use with an Arisona PIC16C74 Microcontroller. Discussions, help and advice of the TTN/Subcontractor resulted in using:

- **A PIC Development Suite** was used for the Microcontroller design. The training covered its introduction and use.
- **An In Circuit Emulator (ICE) was used for verification,**

The ICEPIC simulator/emulator again purchased by the subcontractor cost around 900Euros.

This was easy to use, efficient and cost effective. After the initial learning curve our experience has been that the use of this ICE considerably reduces the development time over other lower cost ICE products. The software was found to be robust and never crashed.

- **A 'C' Compiler for programme design,**

At the commencement of the project the only Compiler available was the MP-C from Bycraft, the subcontractor bought a commercial licence which cost around 900Euros.

- **A PCB design suite.**

The Edwin Design Suite was used at a cost of 1700Eur for the upgrade version with 760Eur for the annual maintenance cost. The agreement reached was that up to 12 PCBs p.a. could be designed within this agreed educational price. There was a long learning curve and libraries were developed over the period of use. It is useful to know that this product is supported on the Internet.

8 EXPERTISE AND EXPERIENCE AND STAFF

Ruskinn Technology is 4 years old and has to-date developed 3 systems, one of which is now the market leader in Japan. The team has in excess of 40 years marketing, mechanical and basic electronic engineering experience. Ruskinn Technology Ltd had, before the FUSE project, experience limited to the use of PLCs and relay applications and very little in electronic engineering. The company has design and manufacturing experience of specialist environmental control systems for micro-organisms based on the use of PLCs. The Incubators are manufactured in-house.

Additional staff with microelectronic experience are now able to manufacture, service and maintain the product line in-house together with the necessary test and evaluation procedures.

9 WORK PLAN AND RATIONALE

Project management was the responsibility of Ruskinn Technology Ltd.

Specification was jointly shared by Ruskinn and the subcontractor who also provided the training.

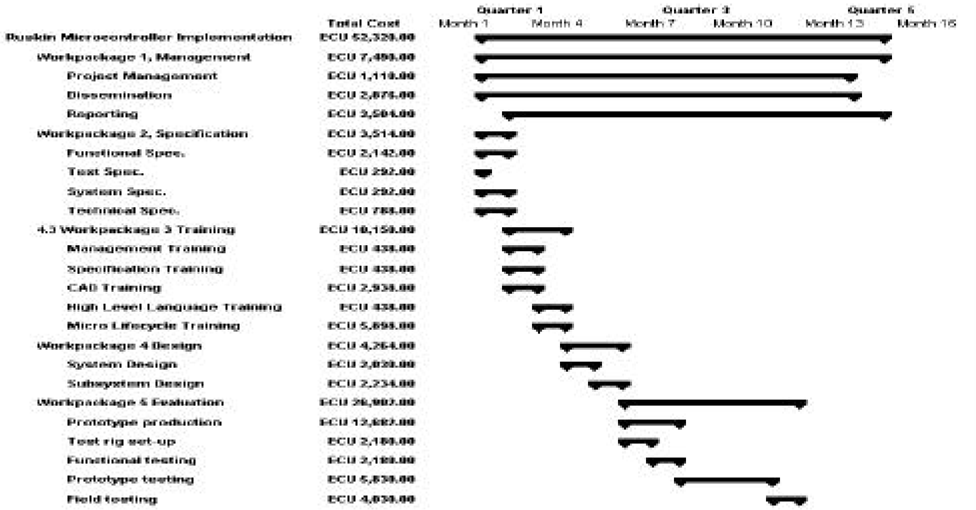
The design was almost totally undertaken by the subcontractor but in close liaison at all times with the first user who was responsible for the on site product evaluation.

Workplan

The following Workplan indicates the schedule planned in the original Technical Annex and the actual man days during the project, the subcontractor costs associated with each workpackage are also listed.

Ruskinn Technology Ltd		Planned Man Days		Actual Man Days	
		Ruskinn	Subcontr.	Ruskinn	Subcontr. Costs euros
4.1.1 Management					
	Plan, Manage	12		12	
	Report,	12		4	
	Dissemination,	6		12	
	Total	**30**	**3**	**28**	**0**
4.1.2 Specification					
	Functional	2		2	
	System/Technical	6		4	
	Test	2		4	
	Total	**10**	**5**	**10**	**1.22**
4.1.3 Training					
	Management/Specification	6		6	
	CAD ('C')	3		3	
	Design for Microcontroller	6		6	
	Evaluation				
	Total	**15**	**12**	**15**	**1.36**
4.1.4 Design					
	Functional Top Down	2		2	
	Software & Hardware Design	1		1	
	Prototype Production	2		2	
	Software Design & Simulation				
	Total	**5**	**12**	**5**	**12.58**
4.1.5 Evaluation					
	Prototype Production	26		14	
	Test Rig	14		5	
	Functional Test	14		8	
	Prototype Test	39		25	
	Full Field Test to Design Spec	14		5	
	Total	**107**	**5**	**57**	**0**
		Planned		**Actual**	
First User Effort		**167**		**115**	
Subcontractor Effort (Man days)			**29**		**15.16**

The Workplan is shown diagrammatically below using Microsoft Project to indicate the project schedule. This was prepared before the project started and used to predict the cash flow in addition to defining the stages of the schedule. Progress and Deviations are reported under the section on monitoring.



Project Costs

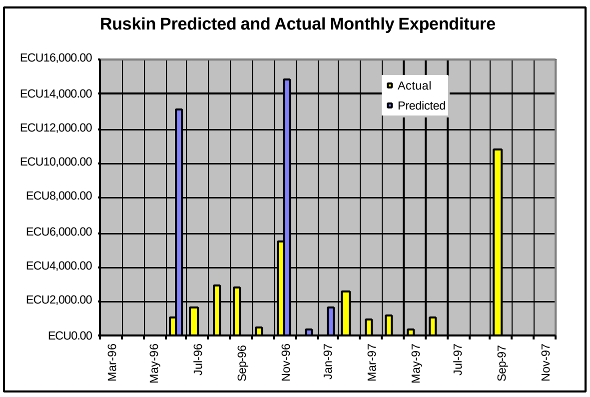
The Application Experiment had an approved budget of 52,320 Eur that included an initial payment of 13,000 Eur (25%). The initial payment was paid on 12 April, 1996.

The predicted costs for the duration of the experiment were planned and scheduled as shown in the information given above under Workplan and include all aspects of the work. Cost statements were made each month together with the reporting.

The attached charts indicate:

1. The predicted and actual monthly expenditure,

2. The predicted and actual cumulative expenditure,



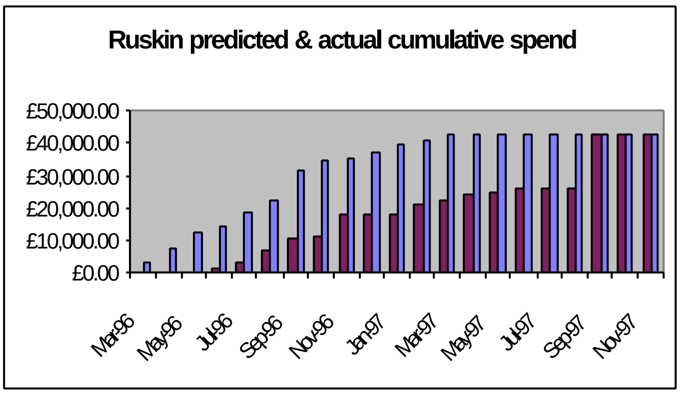


Chart 1 **Chart 2**

Specifically Chart 2 indicates the actual cumulative monthly expenditure.

The final deviation overspend on the budget figure were due almost entirely to the constant changes in the £/Euro conversion rate over the duration of the experiment. The accuracy of prediction and adjustment of working practice especially when associated with an unknown (to us) technology and with such an unpredictable economic environment is commercially acceptable.

Product Costs

The initial key benefit to be derived from FUSE was that of reducing the product cost. The proprietary components required for the electronic control of our existing Concept Plus unit are over 1160Euros. We now estimate the cost of the new microcontroller based electronic components of the product to be under 500Euros. This will prove essential in helping Ruskinn Technology Limited compete and offset the unforeseen effect of a very strong pound sterling.

A consideration, not originally accounted for, is the added value of the new design. The features and flexibility introduced by the new design provide

Monitoring

During the course of the Application Experiment extending from May 1996 to October 1997 monitoring reports were completed and entered on the database.

Management

Ruskinn managed the project throughout and produced 12 monthly reports on time. An article for the European FUSE Newsletter No 4, August 1996 was produced and an article for the TTN Newsletter 'In Touch' October 1996 Vol 1 Issue 2. Additionally Ruskinn contributed their experiences to a TTN FUSE Seminar at Preston.

Specification

Specification training was completed on schedule in June 1996. With the help of the subcontractor a comprehensive, complete, agreed and documented specification was produced by October 1996. This was later than planned but was much more advanced and employed more Microcontroller facilities than was originally planned due to the lack of knowledge of their capabilities by the first user.

Ruskinn Technology recommend that any company undertaking a new, to them, technology should seek clear advice and opinion on this essential aspect of specification before commencing the project. Getting it wrong can delay progress and cost more money than planned.

Training

Training proved to be an invaluable first step in the project. Prior to FUSE the management at Ruskinn Technology Limited had no experience of Microcontroller Design and Project Management. Two staff attended the Management/Specification for Microcontrollers course and the Electronics Engineer attended the CAD Training course using the 'C' Programming Language and 'C' for Microcontroller Design Course during July and August 1996. These provided essential technical knowledge fundamental to understanding subsequent stages of the project.

The EDWIN CAD package was purchased to facilitate continued in-house work on PCB design.

Design

Product design took place between September 1996 and April 1997 and took considerably longer than originally forecast due to the First User inexperience and enhancement of the design specification.

During the project problems were encountered with the available internal memory of the microcontroller. A move to the next generation of microcontroller that had more memory was required as the number of icons necessary to provide an internationally understandable menu for the user friendly interface, without the requirement for a different programme for each country, consumed more memory than was available.

Ruskinn Technology were acutely aware of how essential the design phase was and wanted to get it as near correct as possible first time.
The subcontractor was heavily involved with the design phase and Ruskinn Technology staff worked very closely with the subcontractor to understand each aspect of the microcontroller design. This partnership worked well and proved essential to the success of the project.

Developing sales and production at Ruskinn Technology Ltd severely restricted the allocation of time to FUSE. The result was that the project became delayed as many hours were spent designing the Microcontroller and for Ruskinn Technology to understand the design process.

Working with the subcontractor during the design was productive and has resulted in a prototype that meets the specification.

Evaluation

The design was finalised and the prototypes constructed and tested in October 1997.
Ruskinn Technology Ltd tested the prototype and incorporated the unit into a pre-production Concept Plus to complete field trials. Ruskinn Technology have doubled their manufacturing output during the course of the project and clearly identified the need to add another team member with high level qualifications in microelectronics.

We are currently co-operating with Bolton Institute to locate a graduate under the Teaching Company Scheme who can specifically help Ruskinn Technology capitalise on the results of the project.

10 SUBCONTRACTOR INFORMATION

The choice of subcontractor was determined by the requirements of the project and the companies we knew who had experience and expertise.

Ruskinn required a subcontractor with:

- A wide understanding of available microcontroller technology and design experience,
- Appropriate training facilities,
- Other facilities, which we felt, would deliver a successful project, e.g. CAD Tools experience,
- The experience to give independent, cost effective and impartial advice.

Local expertise determined the choice of subcontractor to be Bolton Institute.

Bolton Institute Technology Development Unit (TDU) is part of the Institute of Higher Education and has been set up to develop Microelectronic Applications support for industrial research, development and technology transfer. The unit, formed in 1992, is currently managing in excess of 3 million Euros of research and development contracts mostly, in UK.

Ruskinn Technology was very happy with Bolton Institute as a subcontractor. Apart from underestimating the time required to help us develop the microcontroller, the quality of work and hand over of information proved to be first class.

Bolton provided access to independent and impartial advice on a cost effective basis through a highly qualified multi-disciplined techno-commercial team of expertise. The unit also provides access to public (i.e. DTI and EC grant-aided assistance) finance.
Bolton Institute also specialise in training and are able to manage projects from the feasibility stage through to the design and prototype stage.

Subcontractor Role in the Application Experiment

The main support for the Application Experiment came from Bolton Institute TDU who provided both management and technical expertise, without which the project would not have run as smoothly. Specifically they assisted us in the evaluation of the appropriate microelectronics and the range CAD tools available. After the selection they provided training in use of ‘C’, with particular emphasis on ‘Good Design Practice’. Bolton then provided the technical input into the design and development of the component. Particular emphasis was placed on how to mix the available technologies.

Specific Subcontractor contribution

Bolton Institute TDU, Microelectronics Design Centre, was responsible for the design of the microelectronic components of this Application Experiment. The TDU produced:

- The Functional, System, Technical and Test Specifications with assistance from the first user.
- Sourced the components to be used in the design.
- Designed the microelectronic hardware.
- Produced the circuit schematics using EDWIN CAD system.
- Produced printed circuit board artwork designs, using the EDWIN CAD system, for manufacture by the PCB manufacturing company, Lyncolec Ltd.
- Designed the software for both the microelectronic boards using In-Circuit Emulation (ICE) techniques and programmed the system in the ANSI C high level language.
- Evaluated the design using a test rig consisting of switch inputs and LED relay driven outputs.
- Produced the system documentation, for presentation to Ruskinn Technology Limited to assist them in gaining a full understanding of the system structure and performance.

The documentation included:

  - Functional, system and technical specifications.
  - Circuit diagrams.
  - PCB artwork.
  - Sample boards fully populated and working to the agreed specifications.
  - Design notes.
  - Software listings and disk containing source and compiled code.

The TDU Microelectronics Centre provided the training courses in addition to working with the staff of Ruskinn Technology during the specification and design phases of the Application Experiment.
The following courses were delivered to the company:

  - Managing and Specifying Microcontroller projects,
  - Introduction to Microcontrollers,
  - ANSI ‘C’ programming course,
  - ANSI ‘C’ for microcontrollers course.

Ruskinn Technology Contribution

During the project:

- ♦ Ruskinn Technology managed the project throughout by planning the schedule of tasks and deliverables, budgeting, costing and reporting the stages of development,
- ♦ Their knowledge of market requirements and discussions of the technical specifications to satisfy customer demands were essential to the functional, technical and test specification,
- ♦ Training in microcontroller programming, using ‘C’, in the transfer of new technology required

for Ruskinn staff to be trained adequately,

- Evaluation of the product was undertaken by Ruskinn both in initial testing and field trials,
- The modifications required to meet different market specifications within the initial design has been carried out by Ruskinn Technology to enable three new products to be marketed in :
- Europe, USA, UK. These are in addition to the Asian market, currently in a downturn (1998).

11 BARRIERS PERCEIVED

The Ruskinn product line needed new technology and a reduced cost product to remain competitive.

The main barriers that Ruskinn Technology perceived were the technical and commercial risks an SME must take when expanding into any new field of technology. The economic benefits, in new orders, expected in the future, will demonstrate the value of investing in new skills. Without the support of the FUSE programme Ruskinn Technology would have had to undertake comprehensive training, but it would have taken far longer.

The two barriers confronting and impeding the implementing of new technology are:

a) Technical Risks

The technical risk would have been for us to adopt a new technology without adequate technical knowledge, training and support. This would probably have resulted in the launch of a badly engineered product or service, or worse still in an aborted product.

Additionally, without support, advice and resources we could have adopted an inappropriate technology.

This project gave us the ability to learn how to apply an appropriate new technology in a virtually risk free manner, with highly skilled support and take full advantage of the facilities available from Microcontrollers.

b) Commercial Risks

The commercial risk is primarily the possible damage done to the reputation of the business, as a direct consequence of the technical risks should developments go wrong or take very much longer than anticipated.

Another important commercial risk for an SME is that whilst personnel are undergoing any form of training, they still have to paid, but are temporarily unable to contribute to the income of the enterprise.

The economic benefits, in new orders and business already obtained, and expected in the future, clearly demonstrate the value of investing in new skills. Without the support of the funding programme Ruskinn Technology would, in time, have undertaken a training programme, but it would have taken longer to complete.

12 STEPS TAKEN TO OVERCOME BARRIERS

The two factors which Ruskinn consider to be important to the successful project outcome were;

- funding, and
- subcontractor choice.

Commercial Barriers
Support funding allowed Ruskinn Technology to overcome many of the commercial pressures expected in undertaking a totally new venture, however, strict budgeting and management was still necessary to control the outcome.

Initial planning of the project using the project procedures introduced to us helped identify and minimise the number of unknown difficulties.

Commercially the enterprise has no choice other than to forgo the income earning potential of staff whilst they are undergoing training, however, funding does cover the direct costs of the relevant staff during the training programme.

Funding gave us the ability to learn how to apply a new technology in a risk free manner, with expert support.

Technical Barriers

Throughout the project assistance from the subcontractor helped us avoid many difficulties in the following technical areas:

- **Specification**
  Ruskinn were able to develop a higher specification product than originally intended at the initial stage of specification, at the expense of extending the project.
- **Training**
  Training in new technology is essential and the choice of subcontractor appropriate.
- **Design**
  We were not competent to undertake the design using microelectronics and needed independent advice and expertise.
- **Staff availability**
  In-house staff availability can be very variable and unpredictable. The use of a subcontractor alleviates this during important phases of the project and allows a degree of freedom in the deployment of resources.

13 KNOWLEDGE AND EXPERIENCE ACQUIRED

The knowledge acquired is summarised in the following:

- Skills have been acquired in the management of a new technology project,
- Ruskinn staff have CAD tools knowledge and High Level programming language skills,
- Design and development of microcontroller systems is better understood,
- Company production costs have been reduced and increased output has resulted from incorporating microelectronics into the product,
- Comprehensive and significant business advantages acquired. (not easy to copy our product designs).

14 LESSONS LEARNED

- Investment in microelectronics design and the development of in-house skills make a business stronger by improving the competitive position and profitability.
- Projects like FUSE require management time. Careful consideration must be given at the outset to allocation of this time particularly where the SME is very small and with rapidly expanding sales.
- External expertise is essential and selection of subcontractors needs to be a careful process. We believe subcontractors need to be involved in specification, design and training workpackages.
- Ruskinn Technology recommends that any company undertaking a new, to them, technology should seek clear advice and opinion on the essential specification aspect of the experiment before commencing the project. Ruskinn have discovered that getting it wrong can delay progress and cost more money than allocated in the budget.

- Consideration has to be given to the design phase. Ruskinn Technology Limited originally severely under-budgeted this aspect through inexperience and had to reallocate funding. We chose to do this to get the design right and we achieved this objective.
- Technical problems were encountered with the available memory of the microcontroller. The move to the next generation of microcontroller with more memory was required as the number of icons required to provide an internationally understandable menu, without the requirement for a different programme for each country, consumed more space than was available.
- Investment in microelectronics is essential to keep a product lead.
- There have been many '*spin off*' benefits of our newly acquired skills:

  Other new product ideas have been generated,
  Design rationale has changed,
  We can now talk the same language to the electronics industry.

15 RESULTING PRODUCT, INDUSTRIALISATION AND REPLICATION

The subcontractor provided the hardware and the software design, the circuit schematics and the PCB artwork. Three working prototypes have been produced as a result of the project. These continue to be subject to comprehensive and extended field evaluation trials.

The new product design is modular, flexible, has new features and is user friendly.

The prototype products have been available since late 1998 and a production version is planned for mid 1999. The cost of the new product is estimated to be 50% of the existing product.

The advanced specification developed with its flexibility and lower cost will guarantee the medium term future for our products.

Internal replication is being implemented as the product can be customised over a range of requirements based on the three products within the family:

- Bugbox (a simple low cost entry level incubator),
- Concept 300,
- Concept 300 Plus.

Redevelopment of the range of products to use the microelectronic expertise and experience gained during the project is in hand. These products have opened up new markets in complimentary areas within the medical field.

16 ECONOMIC IMPACT AND IMPROVEMENT IN COMPETITIVE POSITION

Ruskinn Technology has become a profitable company after three years of product and market development. This latest project has enabled business to take on the development of products using microcontrollers with a positive impact on profitability. Without the reported project this would not have happened at this stage in the life of the business.

The result is that we are able to look forward to cost savings that we estimate will improve our gross profit margin by 4-5 % in 1998/9. The technical features the inclusion of a microcontroller has delivered will ensure that the 25% growth in sales will continue and will be reflected in our profits.

The primary new end product, for the Concept Plus anaerobic workstation, produced as a result of the AE uses two Microcontroller PCB units and associated software.

The first PCB is a control and monitoring card which can be applied to the family of anaerobic workstations currently manufactured by Ruskinn Technology Ltd. The second PCB implements a sophisticated user interface to be marketed in the top machine of the range, i.e. the Concept Plus Anaerobic Workstation. The hardware and software can also be easily adapted by reducing the complexity of the design to provide a bottom-of-the-range simple, lower cost user interface.
The microelectronic design and also the knowledge transferred to Ruskinn Technology Ltd will be applied to other new projects.

The total cost for the equipment in the new design is 500 Eur representing a cost saving of about 50%.

One major benefit of the new microcontroller designed product is that it will enable us to increase output by up to 30% without additional engineering staff. This is due to reduced assembly time. This will have a significant impact on profits as sales increase.

The new product is estimated to have a life of approximately 4 years. Current orders suggest a payback period to recover the investment funding of 53 KEur of about 24 months and a three-fold return on investment over the life of the product.

We believe that the design strategy adopted may well allow a flexibility to develop future versions of the product with further added value with a possible extension of life. This would then give added return on the investment.

The project has contributed significantly to the improvement in competitive position and has allowed a small company to acquire new electronic technology and knowledge to facilitate technical improvements that will keep the Ruskinn brand ahead of competition.

17 ADDED VALUE TO THE PORTFOLIO AND TARGET AUDIENCE

Best Practice

Ruskinn Technology now has practical project experience and can help companies replicating by discussing these experiences in the following areas:

The AE can help in best practice by the discussion of the importance of the choosing a subcontractor.
Experience gained in the choice of subcontractor with:

- A Technology Transfer Mission to support first users fully and comprehensively,
- Facilities to meet the project needs,
- Experience to give Vendor Independent and impartial advice,
- Available design support staff in the required specialist technology.

The importance of regular monthly monitoring meetings.
The importance of FU Senior management staff involvement.
Importance of detailed, documented and clear product specification.

Target Audience

The target audience for FUSE information are SMEs with products not yet employing electronic components in their products.

- Specifically small companies with no electronic expertise.
- Small companies who address custom markets.
- Companies requiring subcontracted electronic expertise.

The results of this Application Experiment are generic and can be applied to a wide range of products and types of company.

Documents Available

The following publications have resulted during and since the completion of the application experiment:

- Article for European FUSE Newsletter No 4 August 1996.
- Article for TTN Newsletter 'In Touch' October 1996 Vol 1 Issue 2.
- TTN FUSE Seminar at Preston.
- A Flyer for distribution by the TTN to interested company's