

*Vitervacuum srl*

*Via Santa Maria in Silice, 13*

*01100 VITERBO*

FUSE DEMONSTRATOR DOCUMENT

APPLICATION EXPERIMENT No. 311

“

**VACUUM FUMIGATION PLANTS  
MICROPROCESSORS IMPROVE MULTIGAS CONTROL IN ORDER TO FULFILL EC  
REGULATIONS**

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## **Ae Abstract**

Vitervacuum (turnover 400KECU) is an electromechanical company founded 40 years ago, with 6 employees, that manufactures fumigation plants and packing machinery (industrial sector: tools and machinery production for food, beverage and tobacco processing). Before the project the expertise of the company was mainly related to the manufacture of mechanical parts such as large vacuum chambers and the assembly of mechanical subsystems.

The company delivers to European, North-African, Asian and South-American food processing enterprises fumigation plants used to exterminate parasitic mainly from food and tobacco .

The objective of the experiment was to include into the main machinery (completely mechanical) manufactured by Vitervacuum srl, the VACUUM FUMIGATION PLANT, four commercial microprocessor-based electronic boards (386 based board, data acquisition board, relay output board, digital input board) to control the whole process by multi-gas sensors.

These sensors have to check in real-time, during the process of vacuum fumigation, the concentrations of the toxic gas that will be involved in the disinfestation process. The control boards have to monitor the concentration of the gas in all the phases of the fumigation process. The process development data are stored by the computer and can be printed out.

The application of electronics allowed an upgrading of all the existing plants to fulfill the EC regulations. Since the alternative for our customers would have been to close the plants, this project was strongly needed. Moreover the experiment also increased the technical and managerial capabilities of Vitervacuum s.r.l.. The budget was 21.5 KEUR and the project lasted for 12 months as planned.

For what concerns the economic benefits of the AE, the ROI (Return on Investment) was of 864% over the next three years, with a payback period of less than one year.

**Keywords and Signature:**

Microprocessor

Tools and machinery production

Fumigation plants

Disinfestation process

Gas control

*Signature: 2 0183 555 0410 1 2953 1 29 1*

## **1. Company name and address**

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## **2. Company size**

3 employees plus the legal representative and his two sons, a temporary manager and some consultants.

The number of internal people involved in electronic design and assembling is one.

The company turnover is 400 KEUR.

## **3. Company business description**

***VITERVACUUM srl*** designs, manufactures and sells agriculture and food processing machinery at its single-site plant in Viterbo.. In particular it gives its contribution in the fight against the infestations of many products such as cereals, chestnuts, cocoa and coffee beans, chamomile, legumes, seeds generally, tobacco, spices, unripe hazel, almonds, maize, pasta, carpets, furs, books, paintings, wood articles, old furniture, ecc.

The company's products are fumigation plants and packing machinery..

VITERVACUUM SERVICE srl has been founded with the mission to maintain and upgrading the existing plants, both packing and fumigation.

The company industrial sector is “Tools and Machinery” (PRODCOM code 29)

#### **4. Company markets and competitive position at the start of AE**

*VITERVACUUM srl* is a European leader in the vacuum fumigation market. The sales of Vacuum Fumigation Plants were more than 80% of the company sales in 1995 and 70% in 1996. *VITERVACUUM srl* is the only Italian enterprise in this market and it has the 80% of the Italian market and the 20% of the Mediterranean market. Unfortunately the political situation of some of the North Africa Countries ( for example Algeria) has pushed down the orders for new machinery.

The world food machinery market is expected to grow annually with 10-15%.

It has to be noticed that the each vacuum fumigation chamber is produced on the client demand, depending on the kind of product to be processed.

The customers of *VITERVACUUM srl* come from different countries, such as France, Spain, Algeria, Tunisia, Egypt, Bahrain, Greece, China, Argentina, Brazil and of course Italy. These vacuum plants can be used for different products, such as food product, tobacco as well as musical instruments or mummies. In fact the types of customers of *VITERVACUUM srl* are food manufacturing enterprises as well as tobacco manufacturers and museums.

The main competitors are North America, French, German and Tunisian companies. These competitors normally make use of a microcontroller based acquisition system.

The Italian and European markets are restricted by the European Union Rules on the allowable released quantities of the toxic gas used in the fumigation process. These requirements are strictly mandatory and almost all Italian plants in their present configuration could be closed.. The right price and the right features of the fumigation equipment were the strength of the product that allowed the company to be leader in such a particular market. The more precise control of toxic gases attained thanks to

microcontroller technology will enable the company to compete with success, as the equipment will be able to comply with the more stringent EC regulations.

*Economic history over the past 3 years*

<b>Current Product</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
Turnover current product (kEUR)	400	420	200
Cost current product (kEUR)	300	315	150
Profit current product (kEUR)	100	105	50
No. of current products sold	5	4	2
Market share current product	20%	20%	15%

In 1998 the AE product pricing falls to 50 KEUR.

Competitive weaknesses of AE product:

- lack of control of toxic gases
- not compliant with EC regulations
- need of manual intervention by an operator

-Competitive strenghts of AE product:

- user friendly
- low price
- very effective for what concerns the extermination of the product too be processed

**5. Product to be improved and reasons to innovate**

The product to be improved by the inclusion of a microprocessor-based system is the VACUUM FUMIGATION PLANT.

These plants are composed by a vacuum chamber of size dependant on the customer needs (from few cubic meters to tens of cubic meters), pumps, filtration group with activated carbons and auxiliary equipment (Fig. 1).



Fig.1: fumigation plant

The process can be described as follows :

1. In the chamber, previously filled by the products, the vacuum will be done.
2. The toxic gas is dosed and then inserted into the chamber.
3. After a proper time, the chamber is filled by air. This air, used as carrier, will be filtered through a series of activated carbons to catch the toxic gas, thus cleaning the air.

Vacuum control and toxic gas dosing are monitored by mechanical pressure sensors.

All dosing procedures are manually performed by an operator.

Position and status of all valves and pumps are checked by an operator.

Functions not performed and parameters not monitored in the actual system are:

- identification of the operator( it is worth noting that the operator has to have a particular license to operate with toxic gasses).
- time of the exposition of the product to the toxic gas.
- concentration of the gasses during the unloading in the atmosphere phase.
- total unloaded quantity of toxic gas.
- Total operation time of pumps (for maintenance).

The vacuum fumigation plants are manufactured depending on the needs of the customer. Most of them require a manual or semi-automatic plant, because they are not familiar with electronic technologies. In particular, in the case of North Africans clients, their plants are located in an extreme environment with low technical level

personnel and they do not need more sophisticated plants. In the case of European clients, the introduction of electronic technologies will provide them with an European standard vacuum fumigation plant in order to continue their business by a safe and legal plant. The AE will develop only the electronic control equipment with a managing, monitoring and alarming of all the main operations of the vacuum fumigation process. The improved electronic part will be also used to update the existing fumigation plants.

Actually, the involved toxic gas for the killing of the parasites of the products is the **CH<sub>3</sub>Br (methyl-bromide)**. This gas is very efficient in this case but researchers discovered that is *dangerous for the ozonosphere of our planet*.

In fact, as ruled by the Law of the Italian Republic no. 549 dated 28 Dec. 1994 and the Decree With The Force of Law dated 12 July 1990, the allowed unloading of the residual gas in the atmosphere is strictly controlled and periodically revised. On the other hand, the Regulation of the European Union no. 3093/94 dated 15 Dec. 1994 states that the production and the consumption of **CH<sub>3</sub>Br** have to be controlled and gradually reduced during next years. For these reasons, **VITERVACUUM srl** has begun from 1993 a research project in cooperation with Universities and Institutes of Italian National Council of Researches to use alternative gasses. Future updates of the plants will be easy using the developed electronics and will ensure a return of the investment for the First User and for its customers.

In a few words, **VITERVACUUM srl** proposed this Application Experiment to offer to its customers an electronic system to control and, consequently, to fulfill the European Union requirements. The alternative for our customers would have been to close the plants, hence the need for the project. Moreover, The revenue of the enterprise is strictly related to the sales of this product. Without the innovation introduced by the A.E. a significant decrease in the sells was foreseen. The A.E. was a real need for the company.

## **6. Product improvements**

This Application Experiment has the objective to include into the main machinery manufactured by *VITERVACUUM srl*, the VACUUM FUMIGATION PLANT, one microprocessor-based electronic board with other auxiliary boards to monitor the whole process by multi-gas sensors. The system consists of four commercial microprocessor-based electronic boards (386 based board, data acquisition board, relay output board, digital input board). The boards are assembled in a PC/ISA bus case and connected with an interface 4-20 mA to the sensors.

These sensors have to check in real-time, during the process of vacuum fumigation, the concentrations of the toxic gas which will be involved in the disinfestation process. Moreover, these sensors have to be located in several places inside and outside the plant to ensure a release of the residual gas under the stated values given by European Union regulations.

The control boards have to monitor the concentration of the gas in all the phases of the fumigation process. In addition, this system will control safe electromechanical equipment to guarantee a safe work environment. Moreover, these boards will give the required flexibility to adapt the monitoring process of the release in atmosphere of different toxic gasses to the stated values established by the local regional authorities.

This Experiment made use of commercial microprocessor-based boards. These boards will condition and acquire the analogue signals coming from different sensors located in several places of the plant. These sensors will detect the concentrations of the toxic gas involved in the fumigation process and other parameters such as temperature and humidity. The sensor and their control units have been properly interfaced with the acquisition board. The data acquisition board has been driven by a stand-alone 386-based microprocessor board. Figure 2 shows the architecture of the system.

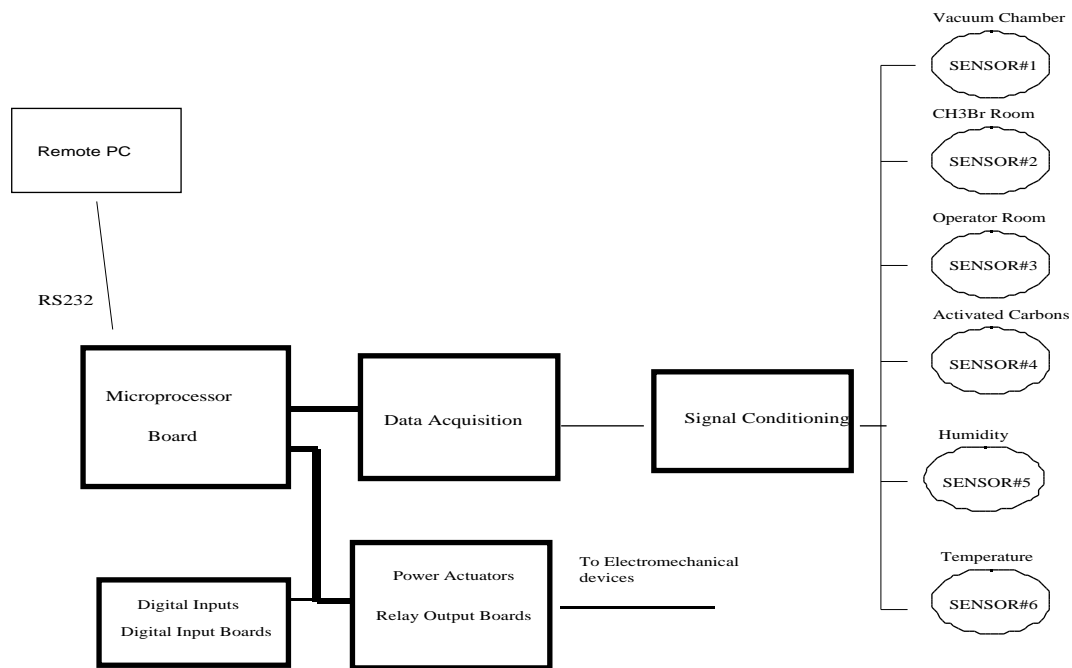
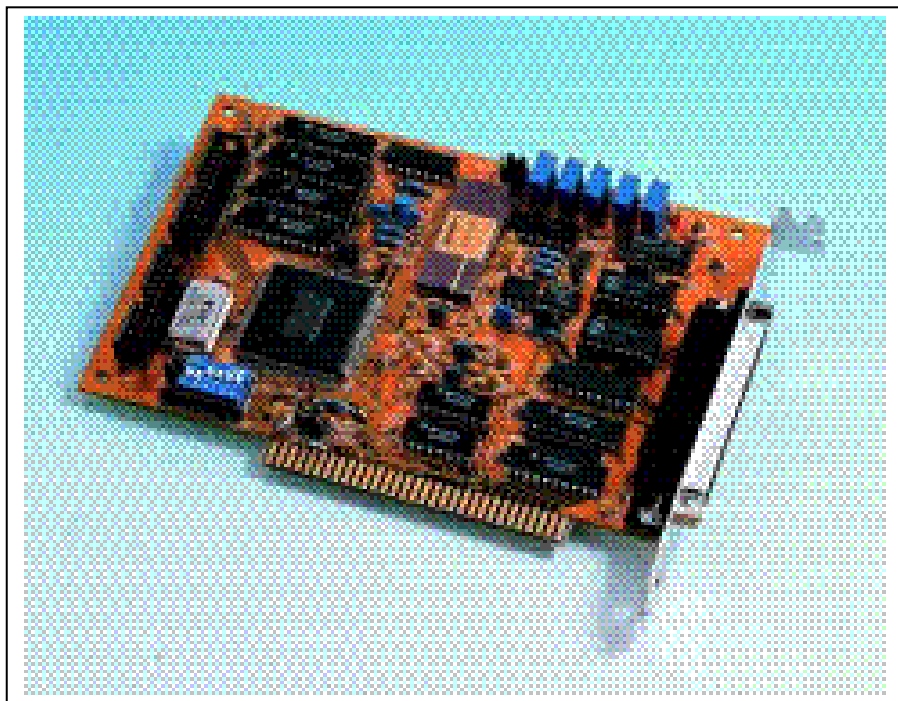


Fig. 2. Architecture of the System.



This microprocessor-based board controls by a program embedded in the board itself. This software drives the data acquisition board, receives the sampling data from the sensors and transmits these data to a remote Personal Computer by a standard

communication interface. In addition, this software activates the Relay Output Board which is connected to Power Actuators, such as pumps, electromechanical driven doors, safe equipment. The control software can check and monitor the parameters of the fumigation process and the air cleaning system by the activated carbons.

The following table shows the added functions of the new product and parameter control improvements. Accuracy of measurement acquired by the new system is 0.01% of FSR (Full Scale Range) at minimum gain, and 0.04% of FSR at maximum gain.

<b>FUNCTION</b>	<b>COMMENTS</b>
Check the identification of the operator( it is worth noting that the operator has to have a particular license to operate with toxic gasses).	Not performed in actual plants
Choice of the type of gas (Phosphin or Methyl-Bromide).	Not performed in actual plants (only one gas used)
Input of the gas concentration and check the correspondence between centimeters the gas column and ppm (Methyl-Bromide) or quantity of Phosphin and ml/mc.	Controlled by an operator in actual plants
Check the temperature inside the vacuum chamber and outside in the location of the activated carbon filter (these parameters are critical for the process with the Phosphin).	Not performed in actual plants (not required for Methyl-Bromide based plants).
Check the position ON/OFF of the valves.	Controlled by an operator in actual plants
Check the status of the pumps and switch on/off the pump.	Controlled by an operator in actual plants
Check the number of hours of operation of the pumps, for maintenance.	Not performed in actual plants
Check the time of the exposition of the product to the toxic gas.	Not performed in actual plants
Check the concentration of the gasses during the unloading in the atmosphere phase.	Not performed in actual plants
Calculate the total unloaded quantity of toxic gas.	Not performed in actual plants
Store all the quantities of the fumigation process.	Not performed in actual plants

Print a report of the process by day or week.	Not performed in actual plants
Communicate via RS232 to a remote computer, to download the process data.	Not performed in actual plants

The control program was loaded into the 1,44MB Flash/ROM disk in the 386SX CPU card PCA-6134P).

## 7. Choices and rationale for the selected technologies and methodologies

The choices of the selected technologies and methodologies have been guided by the following considerations:

1. The system should have the flexibility to connect to different electronic sensors for gasses, temperature, humidity.
2. The cost of the electronic system is not a strict requirement because the costs of the electronic parts are less than 3% with respect of the total cost of a standard Vacuum Fumigation Plant.
3. The expected number of new systems to be product is about 5/7 per years, for the new plants and 10/20 for the expected modifications of the existing plants.

The technology options considered were the following:

- ASIC (Digital., Analog or Mixed): a suitable technology, but the high production costs connected to it were not justified by the low number of products.
- DSP (Digital signal processing): an efficient technology, but it presented an extremely high algorithm complexity, not advisable for the need of this project, whose final users are not acquainted with high technology.
- Microprocessor: suitable from all point of view, thanks to its ability to check and process the data acquired by sensors and to drive actuators and relays .

Therefore we chose the microprocessor technology and, as suggested by the international panel of EU evaluators during the review process of the proposal, to use commercial PC-based boards to assemble the system.

The Board used in the new systems (all produced by Advantech) are:

PCA-6134P – Half size 386 based CPU

PCLD-785/B, 24 ch. Relay output board.

PCLD-782/B, 24 ch. Opto isolated board.

PCL-818L, Advantech custom microcontroller based acquisition board, 40kHz sampling rate.

Two software have been developed, one running under DOS and the other running under Windows (to cover all the user requirements).

The Tools used during AE are:

- board drivers and tools provided by Advantech for microcontroller board (the only choice available for acquired boards).
- DOS based BASIC compiler (QBASIC).
- Windows Basic compiler (VISUAL BASIC).

BASIC selection for programming language is due to the powerful graphical support for windows programs of Visual Basic that reduces developing time (other C-based solutions need more time and experience to obtain the same results).

During the on-the job training phase, subcontractor provided the first user with the necessary methodologies to install, manage and control an electronic acquisition system.

The subcontractor has given general concrete advises, some of them can be summarised as follows:

- Board installation:
  - Turn the system power off before installing a new board.
  - Use electrostatic protection.
  - Place analog only or analog to digital conversion board far from digital board.
  - Clean board fingers.
  - Leave distance among boards with high power dissipation. Place these boards next to the ventilation section

- Small analog signals protection:
  - Pump and relay produce electrical noise on signals. Filter these noise (if out of the signal band).
  - Use balanced signals if possible (noise is a common mode signal).
  - Isolate acquisition section from other “high power” parts.
  - Use clean power supply
  - Use shielded cable with shield connected only on the driving (out) section.
  - Avoid ground loop.
- How to deal with a dirty industrial environment:
  - Use dust filters on fan inputs.
  - Dislocate a part (closed box) from the dirty environment before opening (to repair or update parts).
  - Fill cable placements with silicon (or equivalents).

Moreover subcontractor has added precise recommendations on the specific sensors acquired by the first user. These advises are not applicable to different sensors or to sensors produced by other vendors

## **8. Expertise and experience of the company**

During its long activity, more of 40 years, *VITERVACUUM srl* manufactured more than two hundred fumigation plants in all sizes, becoming a market leader (Fig. 1).

The main expertise of the company is in manufacturing mechanical parts such as large vacuum chambers and assembling mechanical subsystems.

Vitervacum has not used electronics components before. We were already using consultants for the chemical support. During these years, most of the manufactured Vacuum Fumigation Plants were manual or semi-automatic. This is because some important countries, in particular North Africa, prefer manual plants due to the low technological level of the personnel and the extreme environmental conditions of the

plants. The experience of VITERVACUUM srl in the field of Electronics was limited before the A.E. to PLC application (assisted by an external consultant) to provide the main control panel of the plants. The company had no experience about add-on industrial PC boards for control equipment or higher technologies. No one of the employees of VITERVACUUM had experience in microelectronics.

Two managers, two electromechanical designers and a technician were involved in the project.

## **9. Workplan and rationale**

The project has been divided into five Work packages and 13 Tasks as follows:

### **Workpackage 1 (Management)**

- Task 1 : Project Management
- Task 2 : Dissemination
- Task 3 : Reporting

### **Workpackage 2 (Specification)**

- Task 1 : Functional Specification of the system
- Task 2 : System Specification of the components
- Task 3 : Technical Specification of the components

### **Workpackage 3 (Training)**

- Task 1 : Management Training
- Task 2 : Specification Training
- Task 3 : Design Training
- Task 4 : Evaluation Training

### **Workpackage 4 (Design)**

- Task 1 : System Level Design
- Task 2 : Subsystem Level Design

### **Workpackage 5 (Evaluation)**

- Task 1 : Prototype Testing
- Task 2 : Field Testing

### **W1. Workpackage 1 (Management)**

The objective of this Work package was to make the experiment a success and fulfil the ESPRIT reporting regulations. This Work package has been carried out by acquiring the project management capabilities in order to manage the project on time and budget.

*Roles and Responsibilities:*

FIRST USER	Set up experiment management schedules instructions and made reports
SUBCONTACTOR 1	-----

**W1.T1 Task 1 (Project management)**

In this Task a detailed schedule including the planning of the activities was outlined. Planning, and project progress monitoring have been realized with the help of the TTN.

Duration : 12 Months

**W1.T2 Task 2 (Dissemination)**

This Task created a sufficient set of information materials for the TTN and the FUSE consortium to enhance the stimulation of the first use of technologies. This Task has been implemented by writing a demonstrator according to the requirements given by FUSE and a flyer of the improved product.

Duration : 1 Month.

**W1.T3 Task 3 (Reporting)**

In this Task, *VITERVACUUM srl* has submitted its Monthly Reports on the status of the Application Experiment to the TTN. Control meetings, also with the subcontractor, have taken place at the TTN and at **Vitervacuum** premises.

Duration : 12 Months.

**W2. Workpackage 2 (Specification)**

In this Workpackage *VITERVACUUM srl* gave a complete description of the Experiment by using block schemes with functional and electrical specifications of each part of the system.

*Roles and Responsibilities:*

FIRST USER	Complete responsibility
SUBCONTACTOR 1	-----

**W2.T1 Task 1 (Functional specification of system)**

This Task made a specification of the vacuum fumigation process according the toxic gas involved to kill the parasitic insects. In this phase a review of the allowed concentration of the released toxic gasses has been reported in terms of EU regulations and Italian laws.

Duration : Two Months.

**W2.T2 Task 2 (System specification of component)**

In this Task a description of each part of the system has been provided by examining all the possible needs of the clients. This phase was carried out by taking into account the existing vacuum fumigation plants that could be upgraded by this improvement. Some of them are twenty years old and need modification both mechanical and electrical. These requirements are necessary because the installed plants of the clients have different sizes, operating pressure and functionality.

Duration : Two Months.

**W2.T3 Task 3 (Technical specification of component)**

This experiment made use of commercial microprocessor-based boards. These boards condition and acquire the analog signals coming from different sensors located in several places of the plant. These sensors detect the concentrations of the toxic gas involved in the fumigation process and other parameters such as temperature and humidity.

The sensor and/or their control units are properly interfaced with the acquisition board. The outputs of the sensors and/or their control units are voltage or current variations. The sampling data-rate of the acquisition are relatively slow because the phase of cleaning the products and the release of the residual gas phase take a long period of time, for example from 15 to 25 minutes according to the product to be disinfected and the used gas. The data acquisition board is driven by the stand-alone microprocessor board ( 386-based board).

This microprocessor-based board controls by an on board program into the board itself. This software drives the data acquisition board, receives the sampling data from the sensors and transmits these data to a remote Personal Computer by a standard communication interface. In addition, this software activates the Relay Output Board which is connected to Power Actuators, such as pumps, electromechanical driven doors, and safety equipment.

Duration : Two months

### **W3. Workpackage 3 (Training)**

This Work package has been carried out by seminars and short courses on microprocessor-based boards with practical exercises in Electronic Laboratories of the University of Rome “Tor Vergata” – Department of Electronic Engineering, for technicians and short course on economic impact of the new technology in the innovation of the product for managers.

Duration : Six Months.

*Roles and Responsibilities:*

FIRST USER	Attended the seminars
SUBCONTACTOR 1	Realized the training seminars

#### **W3.T1 Task 1 (Management training)**

In this Task the managers of the *VITERVACUUM srl* attended seminars on the evaluation of the economic impact of the new technologies.

Duration : One Month.

#### **W3.T4 Task 4 (Design training)**

In this Task the internal personnel attended a short course on microprocessor-based boards, analogue/digital signal acquisition and relay output boards. This basic course gave the possibility to the personnel to follow during a training on the job the design activities of the subcontractor.

Duration : Five Months.

#### **W3.T5 Task 5 (Evaluation training)**

In this Task the internal personnel attended some practical exercises on test equipment and software debugger in the Circuit Laboratory of University of Rome “Tor Vergata”.

Duration : Two Months.

### **W4. Workpackage 4 (Design)**

This Work package has been carried out by acquiring the selected microprocessor-based boards and assembling the system. The monitor program, loaded into the microprocessor board, has been developed by a high level programming language (BASIC).

Duration : Five Months.

*Roles and Responsibilities:*

FIRST USER	Complete responsibilities
SUBCONTACTOR 1	Assisted the First User in the Design tasks

#### **W4.T1 Task 1 (System level design)**

This Task has been carried out by developing the monitor program to control the fumigation process that has been loaded into the electronic boards. This software has been developed by a high level programming language (BASIC).

Duration : Three months.

#### **W4.T2 Task 2 (Subsystem level design)**

This Task has been carried out acquiring the selected microprocessor-based boards and assembling the system. The interface to the sensors have been properly connected.

Duration : Three Months.

#### **W5. Workpackage 5 (Evaluation)**

*Roles and Responsibilities:*

FIRST USER	Complete responsibility
SUBCONTACTOR 1	Assisted the First User in the Evaluation

This Work package has been carried out by testing the system in a stand-alone condition and in operative production conditions. The first phase has been performed by simulating the sensors signal and debugging both hardware and software. The second phase has been carried out by using the Vacuum Fumigation Prototype Plant of the *VITERVACUUM srl* and an Vacuum Fumigation Plant in normal production conditions.

Duration : Four Months.

#### **W4.T4 Task 4 (Prototype testing)**

This Task has been carried out by simulating the sensors signals in order to debug the hardware equipment and the monitor program.

Duration : Three Months.

#### **W4.T5 Task 5 (Field testing)**

This Task has been fulfilled by carrying out tests on the Vacuum Fumigation Prototype Plant of the *VITERVACUUM srl* and on a manufactured Vacuum Fumigation Plant that has been tested in normal production conditions with different gasses in different concentrations.

Duration : Two Months.

Workplan started in May 1996 :

Activities	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
	M 96	J 96	J 96	A 96	S 96	O 96	N 96	D 96	J 97	F 97	M 97	A 97
<b>Workpackage 1</b>												
Task 1	X	X	X	X	X	X	X	X	X	X	X	X
Task 2												X
Task 3	X	X	X	X	X	X	X	X	X	X	X	X
<b>Workpackage 2</b>												
Task 1	X	X										
Task 2		X	X									
Task 3			X	X	X							
<b>Workpackage 3</b>												
Task 1	X											
Task 4 (original)				X	X	X	X	X				
Task 4 (final)				X	X	X	X	X	X			
Task 5 (original)								X	X			
Task 5 (final)											X	X
<b>Workpackage 4</b>												
Task 1 (original)							X	X	X			
Task 1 (final)							X	X	X	X		
Task 2				X	X	X						
<b>Workpackage 5</b>												
Task 4								X	X	X		
Task 5											X	X

The workplan has been lightly modified as shown in the table. These modifications are mostly due to the technical inadequacy that has been focused during the project.

To overcome this barrier, the manager and the subcontractor decided to spend more time on the training tasks and to plan additional training by other institutions.

These modifications did not delay the scheduled workplan total time and do not modified the planned efforts.

	FU's EFFORT (person days)	Subcontractor (KEUR)
Work package 1	30	0
Work package 2	30	0
Work package 3	30	2.00

Work package 4	150	1.50
Work package 5	70	0.50
<b>Total</b>	<b>310</b>	<b>4.00</b>

The knowledge transfer process has developed in seminars and short courses on microprocessor based boards with periods of practical training in Electronic Laboratories of the Universities for Technicians and short courses on economic impact of the new technology innovating the product for managers.

## **10. Subcontractor information**

The subcontractor role has been fundamental in the selection and identification of the right technologies and for support during the whole project. Our lack of knowledge has been overcome with the help of the subcontractor. (see paragraph steps to overcome barriers). Since Vitervacuum had no experience nor knowledge in electronics it was very important to choose a subcontractor with good training experience. Vitervacuum according with the TTN choose to not purchase specific electronics design tools and to work in collaboration with the subcontractor that managed the necessary software tools.

The subcontractor chosen was the Department of Electronic Engineering, University of Rome “Tor Vergata”. The Department of Electronic Engineering has various experience in several fields of Electronics. In particular, in this AE has been involved the Circuits Laboratory. In this field, the Circuits Laboratory has several experience in the design and test of micro-controlled boards for different applications, from add-on PC boards for control of equipment to micro-controlled boards to control ASIC (mixed analog-digital neural networks) for research activities.

The involved personnel were Prof. Mario Salerno (Chair of Electrotechnics) and Dr. Fausto Sargeni. They have been involved in several European program for SME such as I-SMILE (Micro-controlled Board for Large Area Irrigation Plants, ASIC for Anti-Pollution Equipment for Busses), MEPI (Demonstrators and Competence Center)

and, as partner of Consorzio Roma Ricerche, in Technology Transfer Node. The subcontractor role has been fundamental mainly because he ensured a continuous assistance as training on the job during the whole project duration.

The contract was based on a list of purchase orders:

- A list of deliverables with the agreed amount of effort/cost
- An agreed time-schedule for joint task execution
- A scheduled calendar of periodical meeting

No specific penalties were included.

## **11.Barriers**

The main barriers faced by the company were knowledge, psychological and financial barriers.

The main barrier was the major lack of information about the electronics technologies and their applications. The lack of information often increases the feeling that what is unknown is too complicated.

Consequently the psychological barrier of the enterprise was due mostly to the perception of a technical inadequacy. It is worth to note that VITERVACUUM srl is a very small company and its leader, the legal representative Mr. Ercole Rossi, is over than 70 years old. This technical inadequacy has been focused during the project and the manager and the subcontractor agreed to spend more time on the training tasks and to plan additional training by other institutions.

A further barrier was to interface with an academic institution. The past experience of Vitervacuum srl with an academic/research institution was only a contract to carry out some chemical or bacterial analysis of infected product. This AE has given the possibility to interface the company to an academic institution through an industrial project with training.

Another barrier was the financial one. Vitervacuum srl is a company that designs and manufactures machinery by orders of the clients. In this way, the company life is regulated by a scheduling due to the orders with little time to experiment.

## **12.Steps taken to overcome barriers and arrive at an improved product**

The above described barriers have been overcome by the company.

The knowledge barrier was overcome by the long interaction with the Subcontractor (University of Rome “Tor Vergata”, Department of Electronic Engineering). It is worth noticing that the proposal has been presented in June 1995, while the project started at May 1996. During this period several meetings were arranged between the company and the TTN for a better understanding of the project and to overcome the psychological barrier. The TTN shown the real advantages of the electronics utilisation in fumigation process through a basic training on the electronics technologies and applications. The economic effort to develop the new product and the small size of the enterprise (in terms of resources allocation), represented together with the poor electronics knowledge the main barriers identified. The technical inadequacy, focused during the project, has convinced the manager and the subcontractor to spend more time to the training tasks and to plan additional training by other institutions. The personnel training is continuing, after the end of the AE, by a course on “high power electrical wiring” that the internal personnel is attending during working -time.

Moreover, the FUSE project has given the possibility to interface the company to the University of Rome “Tor Vergata” through an industrial project.

The subcontractor role has been fundamental in the correct development of the project. The training on the job ranged from how to install the board and the sensors to how to program the microprocessor. Other arguments have been how to deal with a dirty industrial environment and how to protect small analogue signals in a noisy environment such as one with pumps and relays.

## **13. Knowledge and experience acquired**

The main knowledge and experience acquired during this Application Experiment are managerial as well as technical.

The managerial knowledge and experience are in the search of electronic boards and equipment suppliers, management of European project, writing reports and respecting the scheduled tasks, contacting with academic people. The TTN (Consorzio Roma Ricerche) was very helpful to support the company in this AE.

The technical knowledge and experience are in the definitions of the electronic specification, realization of an electronic project, assembling an electronic system, designing a software tool. In this case, the role of the sub-contractor ( University of Rome “Tor Vergata”) was necessary to target and focus objectives and training.

The goals of this AE were completely fulfilled by means of upgrading the existing plants and increasing the company technical skills.

#### **2.14. Lessons learned**

Some “lessons” have been learned that might be helpful for other FUs:

1. Choose a realistic technology target. In this AE, it is not important to use the up-to-date technology but the technology you are able to manage, support and to develop.
2. Choose a proper potential work. In some case VSE (Very Small Enterprise) cannot be able to fulfill the tasks because some urgent order must be carried out.
3. Choose the proper sub-contractors. They are very important for the successful of the project.
4. Vitervacuum learned how to assemble a microprocessor based system and also to understand the specification for the software development.

Additional benefits have been the managing of the new technologies, managing and selection of the subcontractors, training of the internal personnel and market development.

#### **15. Resulting product, industrialization and internal replication**

The introduction of electronics allowed an upgrading of all the existing plants to fulfill the EC regulations and the realization of a new product in line with the European regulation.

The “industrialization” of the prototype has been started. It has to be remarked that this product has to be adapted to the customer’s requirement. In this sense the updating of the existing plants is already the product industrialization. Vitervacuum is realizing the plant update for its main customers. The results gained in this AE can be replicated in other products of the Vitervacuum srl. In fact, the other manufactured products, large-volume packing plants, can be surely improved by this technology. The relation with the University of Rome “Tor Vergata” on the Intellectual Property Rights of this project are established by a contract which rules the property of Vitervacuum srl of all the results. In addition, the contract establishes a Non Disclosure Agreement for the publication of the results.

*Schedule to industrialize:*

Finished prototype	May 97		21.5 KEUR	
Product suitable for production	May 97		15 KEUR	
Product in the market	june 97	15 KEUR		<b>Total, KEUR</b>
First product sold	june 98			51,5

**16. Economic impact and improvement in competitive position**

This Application Experiment will give to *VITERVACUUM srl* a strong impact on the market with respect of the European and North American competitors. In addition this experiment gave the opportunity to *VITERVACUUM srl* to offer to its customers a package of modifications and maintenance of their existing fumigation plants to fulfill the EU Regulations. Also during the project development several customers revealed a strong interest in the plant upgrade. Moreover, this Application Experiment gave to the Vacuum Fumigation Plants of *VITERVACUUM srl* the necessary flexibility to adapt the monitoring process of the release in atmosphere of the toxic gas to the allowed values of the local regional authorities.

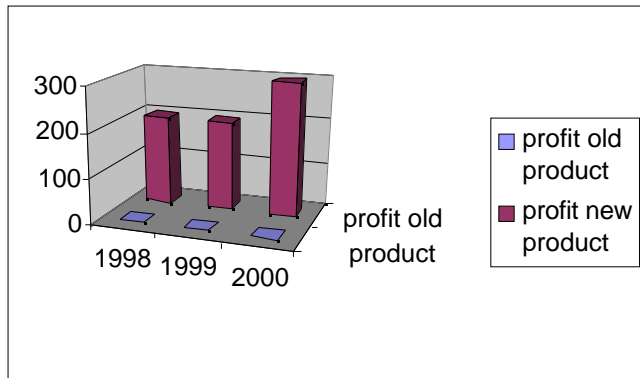
The advertising of the plant improvement realized during the project development resulted in a strong feedback from the customers. This led to a number of plant sales being increased in comparison to the ones described at the proposal time (June 1995).

The present sales table is here reported:

(Please note that sales of current product have not been forecasted since EC regulations would have excluded it from the market, and also that since the product is customised, the price can vary significantly, which explains why the average unit price differs from one year to another)

Projected quantitative impact of the Application Experiment:

<b>Product</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>
Turnover current product (KEUR)	400	420	200	0	0	0
Cost current product (KEUR)	300	315	150	0	0	0
Profit current product (KEUR)	100	105	50	0	0	0
No. of current products sold	5	4	2	0	0	0
Market share current product	20%	20%	15%	0	0	0
<b>Improved product</b>						
Turnover improved product (KEUR)	0	0	0	500	600	700
Cost improved product (KEUR)	0	0	0	300	400	400
Profit improved product (KEUR)	0	0	0	200	200	300
No. of improved products sold (or upgraded)	0	0	0	10	15	20
Market share improved product	0	0	0	22%	22%	25%



*Forecasted economic benefits*

The Return of Investment (ROI) will be of 864% (calculated on the overall total investment of 51.5 KEUR) over the next three years (the ROI on FUSE investment alone would be of 2069%). The extra invested amount of 30 kECU not included in the financial support of EU includes additional training, chemical and biological studies to change the toxic gas (strictly required for the manufacturing of new fumigation plants). In any case a payback period of less than one year is foreseen.

It is very important to underline that the AE will give to the industrial operator in this field and to Vitervacuum Srl, a “chance” to stay in business with a European standard vacuum fumigation plant. Moreover, the AE will give to the vacuum fumigation plants a significant add-on business value that will be very important for the company.

The added value to the customer can be summarized as follows:

- even more user friendly
- compliant with EC regulations (important also for non-European clients providing guarantee of more reliability and safety of the plant)
- reliable monitoring of the fumigation process
- constant recording of the process data

## **17. Summary of best practice and target audience**

The best practice from this AE can be summarized as follows:

- it was the first approach of the company to microelectronics: with the TTN support in different phases of the project the FU succeeded in ameliorating their skills .

- Of course in this upgrading process the external intervention of a Subcontractor with a good training expertise was fundamental.

-Even if the FU is a very small company - in terms of number of employees and of a very specific market demand - it was possible to face and overcome an external barrier (like the new EC regulations). This kind of limitations often provoke the closure of companies that cannot rely on a structure strong enough to face the changes required.

This experiment could stimulate replication among the enterprises that need to introduce an electronic process control. In particular enterprises which need to dose and to monitor the gas concentration in chemical processes with a flexible control system could be the focused target. Moreover this project is a good example of a “non-electronic involved” company that approach for the first time electronics. The Companies with low level of knowledge of electronic system will learn by this project the benefits of the electronics in their machinery for their future business markets.