

**FUSE DEMONSTRATOR DOCUMENT
APPLICATION EXPERIMENT 22964
FUEL PUMP CONTROLLER
Programmable Logic achieves a cost saving of 20%**

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Abstract

LOGITRON has been operating in the gasoline station electronic automation business for over 25 years, covering all activities of product design, manufacturing, sales, installation and maintenance.

It is today an enterprise of 280 employees with products ranging from the core-business gas station control systems and gas hydraulic dispensers to electronic drivers for knitting machines, Electronic Fund Transfer (EFT) products and data collection services. Current technological level is that of digital discrete devices and microcontroller/microprocessor.

Regarding the business of electronic automation for oil systems, PumaHOST product has been marketed for the past 10 years with a 76% share of Italian market and a significant position in international market. Puma HOST (PUmp Management system) is the central management unit that controls both oil pumps and outdoor payment terminals (OPT) in automated fuel stations.

Although very successful in its life cycle, PumaHOST is currently suffering from product maturity. The continued use of the ageing operating system, extended use of HW modules, lack of a state-of-the-art Graphic User Interface and lack of an integrated Convenience-Store (C-Store) management, makes the product at some extent obsolete if compared with the present needs as the emerging Point of Sale (POS) oriented markets. Costs, in particular, are becoming a critical factor in competing against competitive offerings of high-performance low-cost units.

LOGITRON realised that markets where obsolescence of PumaHOST was becoming a matter of fact would not be lost if a new low-cost high performance PumaHOST would be sold either as an alternative or upgraded product.

The best solution to avoid current PumaHOST drawbacks was to redesign its system core: it is the **SPU (Site Processor Unit)** that interfaces the pump management system with the forecourt devices by using both standard and proprietary protocols with the objective to reduce PCB space, complexity and cost, improve the product's performances and easiness of programming.

The company introduced, for the first time, Complex Programmable Logic Device (CPLD technology) to integrate SPU functionalities, previously assembled on three separate ISA compatible boards, onto a single board. This has resulted in benefits like increased system integration and a 21% cut in SPU production costs. The reduction of production costs for the whole PumaHOST system is of the order of 3%.

CPLD also allowed integrating additional functions than previous simply I/O interfacing, like Power Supply Management. The SPU and the overall PumaHOST features, with the new CPLD technology, can be easily reconfigured on board via JTAG serial protocol.

The new PumaHOST product has already been sold and installed with success by LOGITRON.

In addition to benefits on product, the Company acquired very relevant skills regarding fields either technological as CPLD/FPGA and VHDL or the microelectronics management.

The AE has committed the Company for 8 months and for a funded cost of 41 KECU. In front of this investment of 41 KECU for introducing CPLD technology and in front of 18 KECU average yearly cost saving due to the redesigned part, the investment can be recovered with a ROI (total incremental profits on product lifetime/initial investment) of 220% and with a payback period of 1.5 years.

Keywords and signature

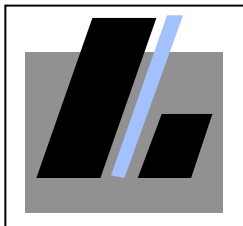
Keywords:

CPLD
FPGA
Digital
CPLD/FPGA Design Process
VHDL
JTAG
Industrial Automation
I/O Management
Point Of Sale Management
Inter-banking

Signature:

3-14205551420-1-2912-2-29-I

I. Company name and address



Company: LOGITRON Srl

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Size: SME
Employees: 280

Project Manager: Eng Leonardo Pacini

Ass. TTN centre: **CESVIT Spa Project:**

AE no. 22964: FUEL PUMP CONTROLLER - Programmable Logic achieves a cost saving of 20%

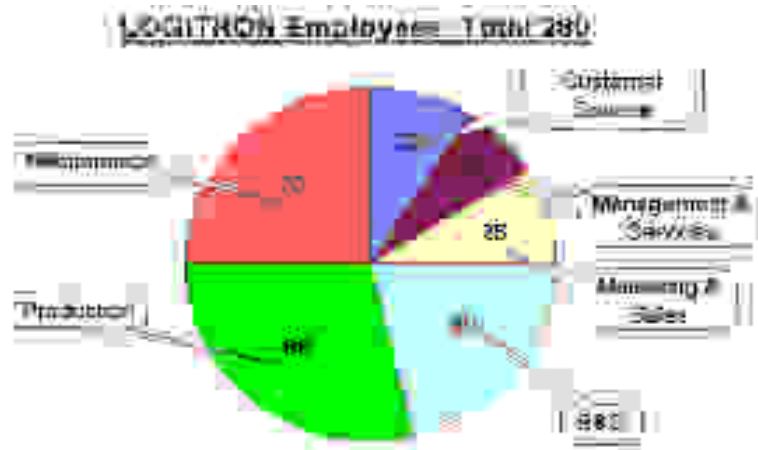
Duration: 8 month
Cost: 41KECU

LOGITRON head office



II. Company size

In their over 25 years experience LOGITRON has grown to an international Company employing today around 300 people world-wide including their affiliate SILA in Argentina. The personnel are distributed according to the following partition:



The Company turnover was 38 MECU in 1996, budgeted 47 MECU in 1997 and forecasted 55 MECU in 1998.

III. Company business description

LOGITRON started their activity in 1969 as a firm specialised in electronic automation systems. Within one year of activity the Company had already chosen what it will be in the future the core business, that is automatic cash accepting machines for petrol dispensing. Next years were marked by a rapid growth of the sales and the product range. In the early 80s the Company started to deal with the International market. In 1987, with the aim to offer to the customers (oil companies) a broader range of product, LOGITRON acquired Meter Control Srl (formerly Gilbarco Italy), one of the leading brands of gasoline pumps, so extending their business to more than just electronic systems.

The Company covers the entire development process, from the new features study phases to the production activities. LOGITRON, in the 1997, has founded a new Company, the OILMAN, which mission is to maintain the entire forecourt devices.

LOGITRON designs, manufactures and markets a wide range of products in the Oil field (core business): 54% of the whole products are oriented to this field. PumaHOST is a product belonging to this Company's field of products.

The table below shows the fields where the Company is involved:

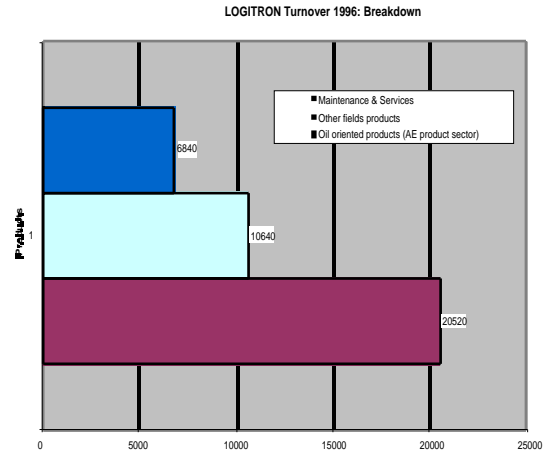
Oil Oriented Products: 54%

- Oil automation products (site controllers): 7%
- Oil hydraulic products (gasoline dispensers): 35%
- Outdoor equipment (cash and card acceptors): 12%

Other Fields Products: 28%

- Automation systems (mobile fleets automation): 9%
- Electronic Fund Transfer products: 2%
- Electronic controls for knitting machines: 6%
- Electronic data collection and processing: 1%
- Electronic Computer Heads for dispensers: 10%

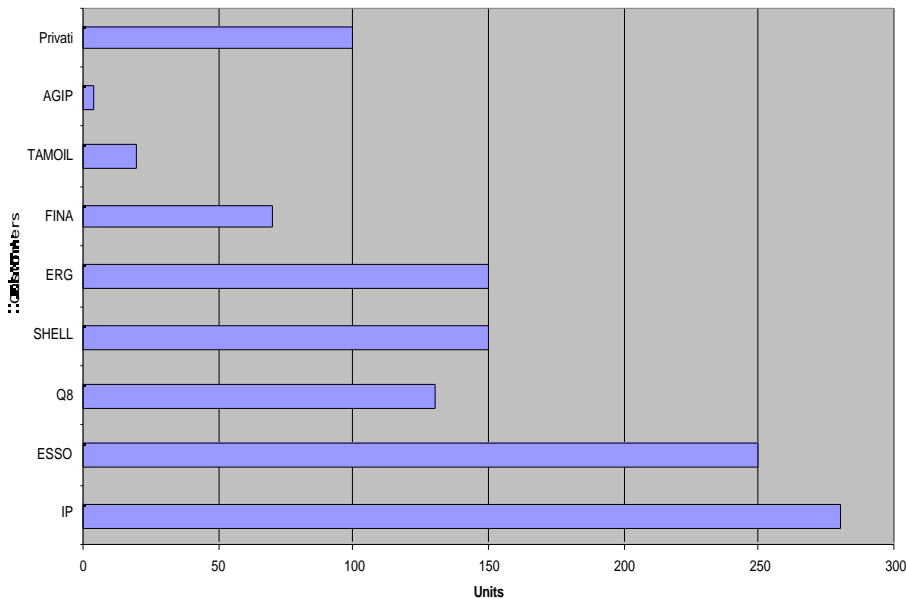
Maintenance & Service: 18%



Logitron is involved in industrial sector classified as PRODCOM 3330 – Industrial Process Control Equipment.

IV. Company Markets and competitive position at the start of the AE

PumaHOST domestic sales



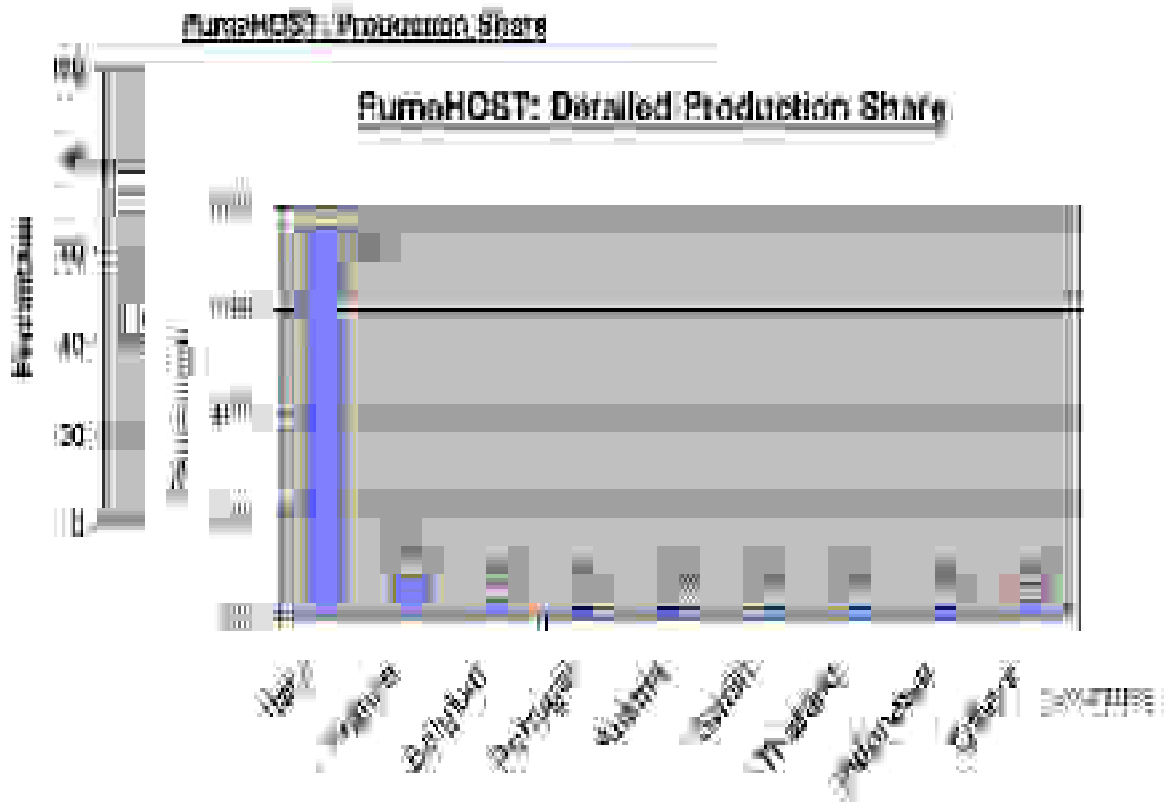
LOGITRON is market leader in Italy Oil Oriented Products.

The principal Oil Companies are the end users of LOGITRON's products. It covers the market with a 76% share. LOGITRON, being the sole Distributor for Italy of Gilbarco Inc. (gasoline pumps), shares also a technological partnership with the latter for joint developments and to offer joint solutions.

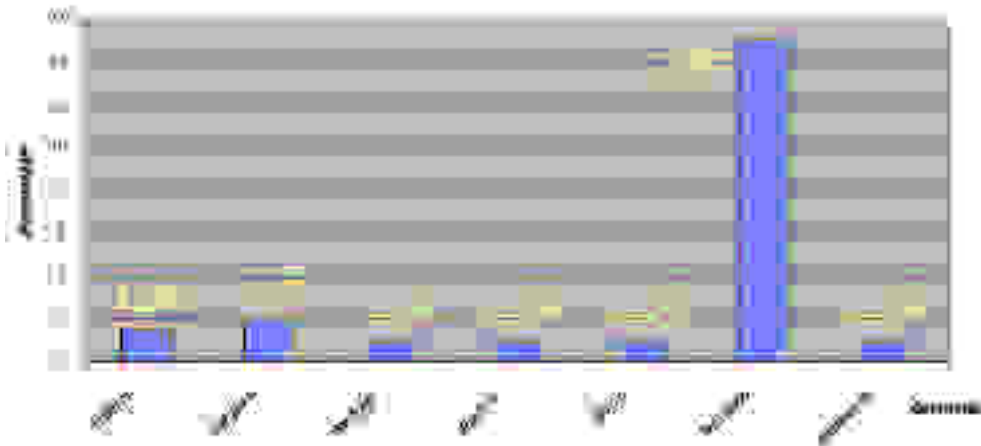
Main domestic customers and related LOGITRON domestic sales volumes are in sided picture.

Referring to PumaHOST, LOGITRON has been operating internationally in the petrol retail automation business for more than 10 years.

The whole PumaHOST production is distributed also in international markets according to percentages provided in pictures. They show how much of Company's PumaHOST production is sold on foreigner markets.



International Market Share



Market share on the international market has been forcedly kept to minimum level due to the high large competitors found in the foreigner market. In Europe PumaHOST has a significant market share in countries where state-of the-art solutions have found fertile ground, as in East European emerging countries. In Asia and Africa,

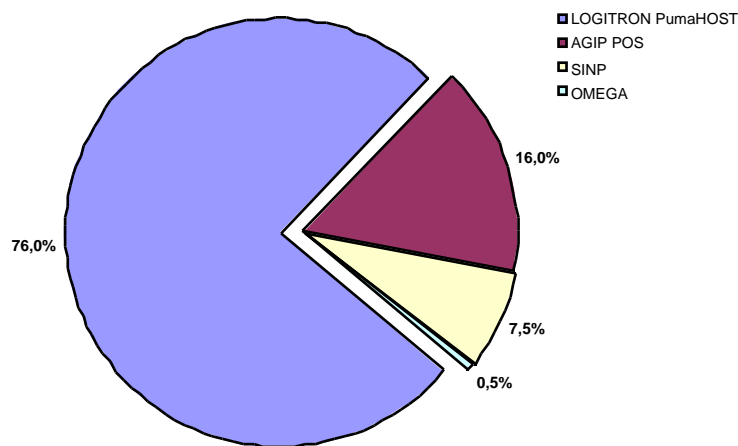
the market configures itself as a very demanding one. LOGITRON commits themselves to gain significant position in these markets.

Competitors and competitive position

LOGITRON is rivalled only by a few competitors, the most important of which is the Italian Oil Company AGIP with their automatic oil systems produced with high technologies because their recent introduction on the market.

Domestic market breakdown and LOGITRON's main competitors are as follows:

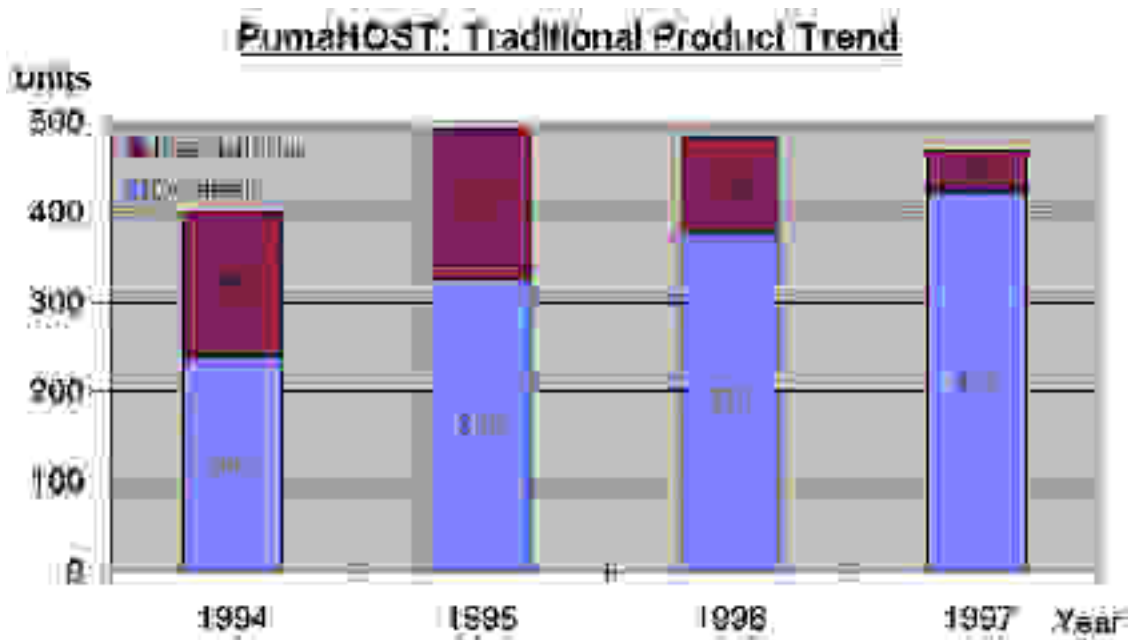
Oil automation control systems: Italian Market



Although very successful in its life cycle, PumaHOST is currently suffering its product maturity. Sales volume for current product distributed along past years with a significant increase in the years 1993-1994. But already in 1995 the Company saw a global negative trend in sales of current PumaHOST, with a significant decrease of units sold in international market.

Adoption of old-styled operating system, extended use of HW modules, lack of a state-of-the-art Graphic User Interface and lack of an integrated C-Store management, make the product at some extent obsolete if compared with present need of emerging Point of Sale (POS) oriented markets.

Cost, in particular, is becoming a critical factor whereby competition is becoming tough in offering high-performance low-cost units.



LOGITRON tried out some product restyling by integrating Company forecourt devices with the competitors devices, using “Black Boxes” to connect them each other. But this couldn't be the definitive solution because each “Black Box” module carried one power-supply, connections, a dedicated case, etc. Hence this solution generated additional costs for production, higher installation time, higher maintenance time and costs.

So as to keep in line with market's demand the old product needed to be enhanced with new technologies and standards (PC-based hardware, touch-screen user interface, Windows NT and LINUX operating systems), but also it needed to be proposed on the market with lower selling prices.

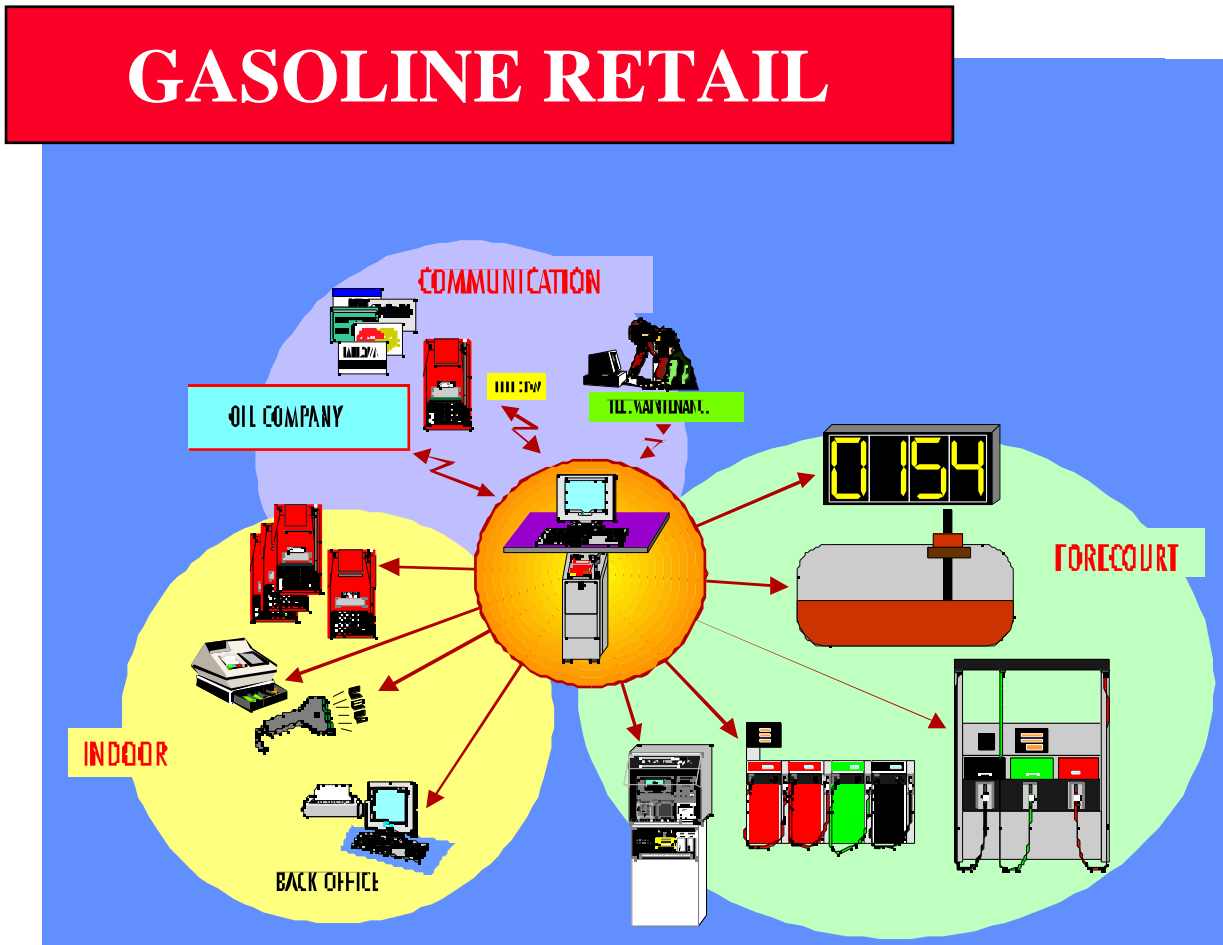
Solution was the dramatic reduction of manufacturing costs using just a CPLD component fitted in an ISA compatible board on the PC motherboard slot. This single board substituted the three different boards for Site Processor Unit, used in the old PumaHOST version.

LOGITRON gained 21% cut of SPU production costs, meaning about 3% reduction of production costs for the whole PumaHOST system

The market success of the PUMA is assured with the lower selling price with respect to the competitors and by the high technological level

V. The product to be improved and its industrial sector

The PumaHOST functions are explained with the following picture.



PumaHOST gets sales data from the pumps and at the same time monitoring the correct operation of the forecourt devices. It is developed on a hardware platform PC based, extended by subsystems (extension boards on ISA bus) interfacing the forecourt devices (pumps, outdoor payment terminals, etc.).

In the current product, made with low/medium integration digital technology, the extensions of PC platform had been realised by means of ISA boards and an external smart module, the Pump Logic Sequencer (PLS).

The system is open for future connection to a tank gauge monitoring device and outdoor payment terminals.

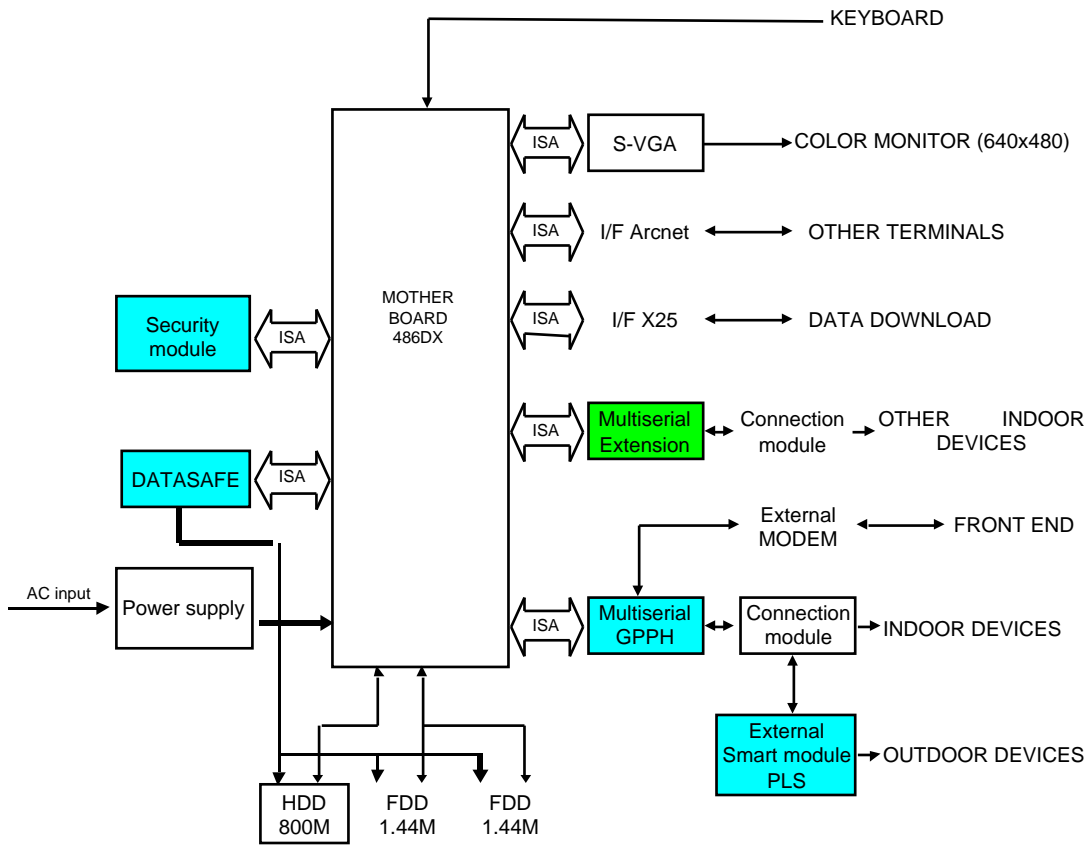
PumaHOST is connected to keyboards (standard and/or customised) and printers for local reporting and ticket issuing.

Puma Host has a modem connection that is used for all purposes of data communication to/from the station; data communication can simply use telephone lines.

Through this connection a tele-maintenance feature is available and LOGITRON can use it to access the system, check from remote the correct functioning.

PumaHOST core is the SPU that performs the I/F to external devices. The SPU is realised in a 3 boards set and represents the bottleneck of the whole system. The latter is the object for this AE.

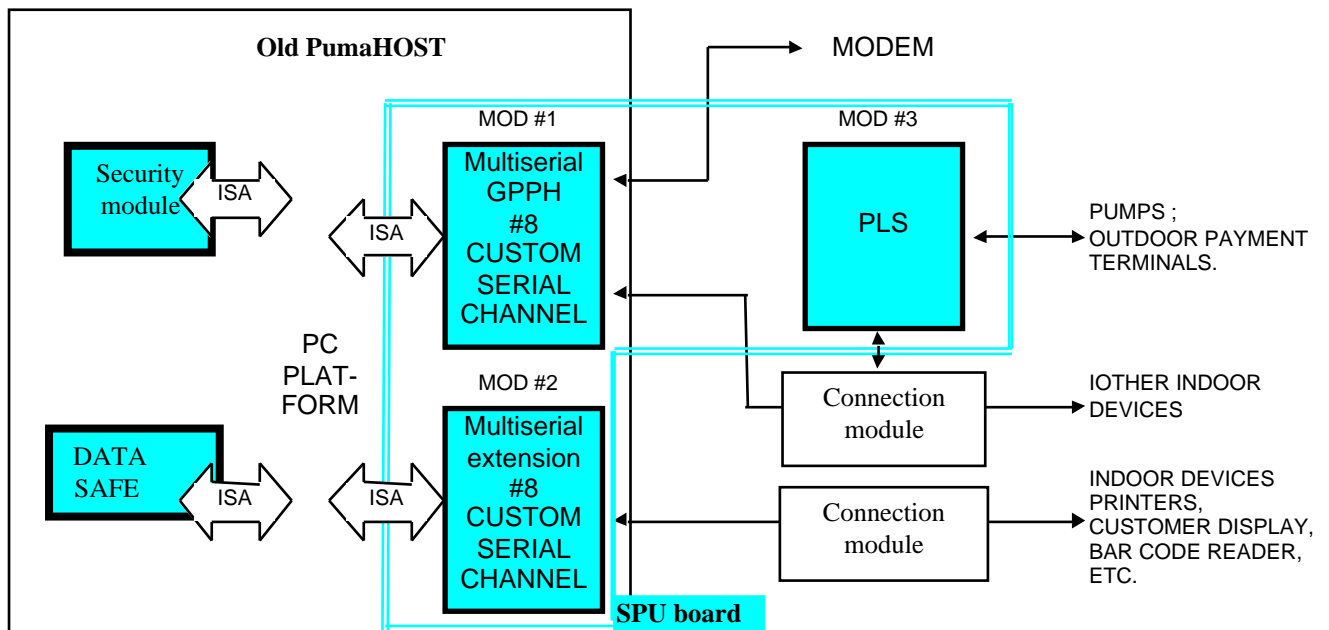
The technology used for the current product is the conventional digital logic and serial interface with the main board and terminals; the boards are realised in THT and SMT technologies.



- Implemented in new SPU module
- Directly controlled by new SPU module

PumaHOST Architecture

Zooming on the system section, that was relevant to the AE development, you can refer to the following picture:



Old PumaHOST functional description and characteristics

Module #1 allows handshaking with modem, with PLS used as intelligent driver of forecourt area devices (pumps, outdoor terminal payment...), and with fuel tanks. This module is placed in a PC slot.

Module #2 allows handshaking with indoor devices like ticket printer, bar code reader, customer display, EFT terminal for payment with magnetic cards etc. This module is placed in a PC slot too.

Module #3 called PLS, is an intelligent device, which, under Host management, directly pilots electronic pumps and outdoor payment terminal. This module is external from PC and it's connected through a customised protocol current-loop based. Modules #1, #2 e #3 are produced with HCMOS low integration technology with a considerable occupation on the board.

The main objective for the innovation of the product is to design an ISA board that transform a PC based system in a service station controller with a lot of improvements as:

- easy re-configurable characteristics for different customers' needs without redesign
- cost and time to market reductions

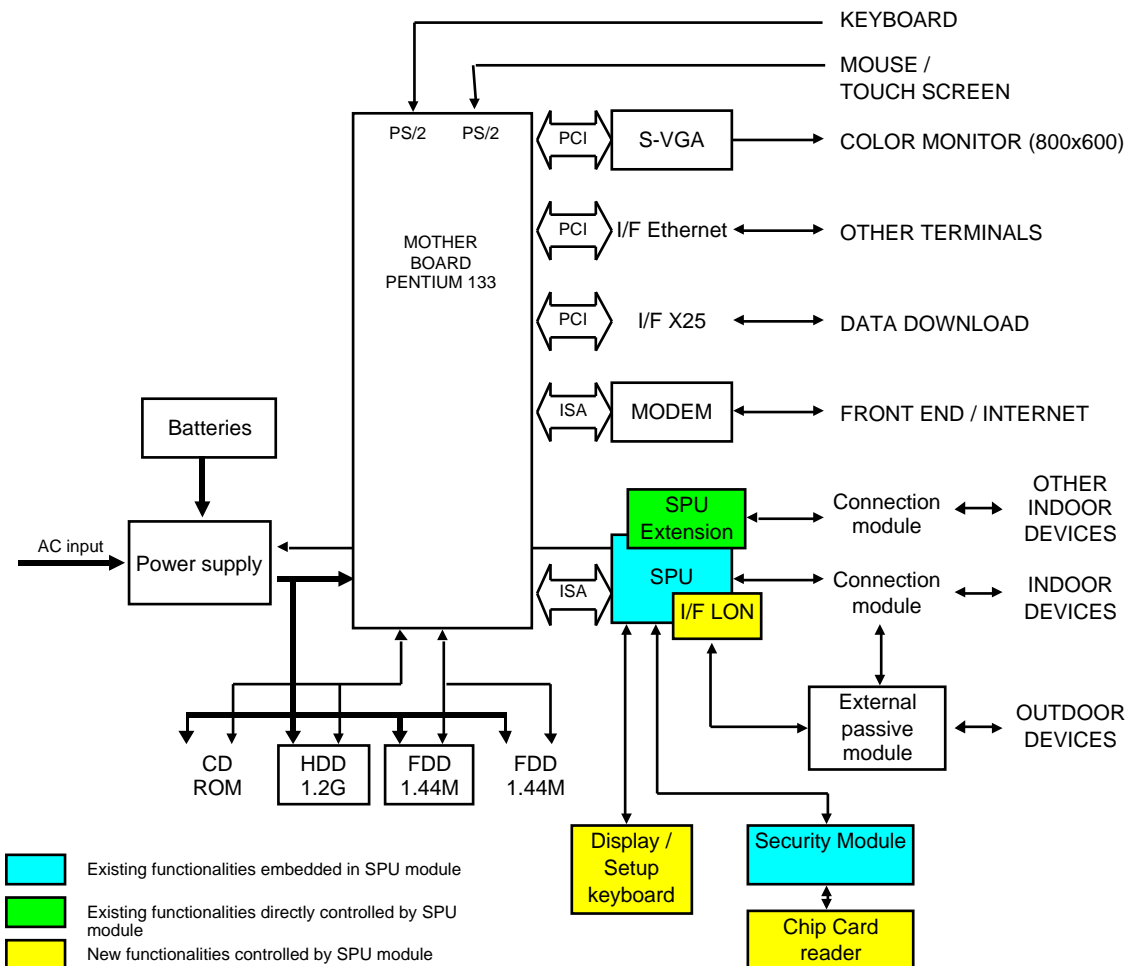
The new CPLD technology allowed to integrate the #1, #2 modules, and most of functionality of module #3 in SPU board thus concentrating all the digital sections with low integration technology in new CPLD device.

VI. Description of the product improvements

The product related to this AE is the SPU module that meets the objective to produce an ISA board that transforms a PC based system in a service station controller. As the picture shows, the capability of overall system had been improved and all the customised module controls had been assembled in one board: SPU module.



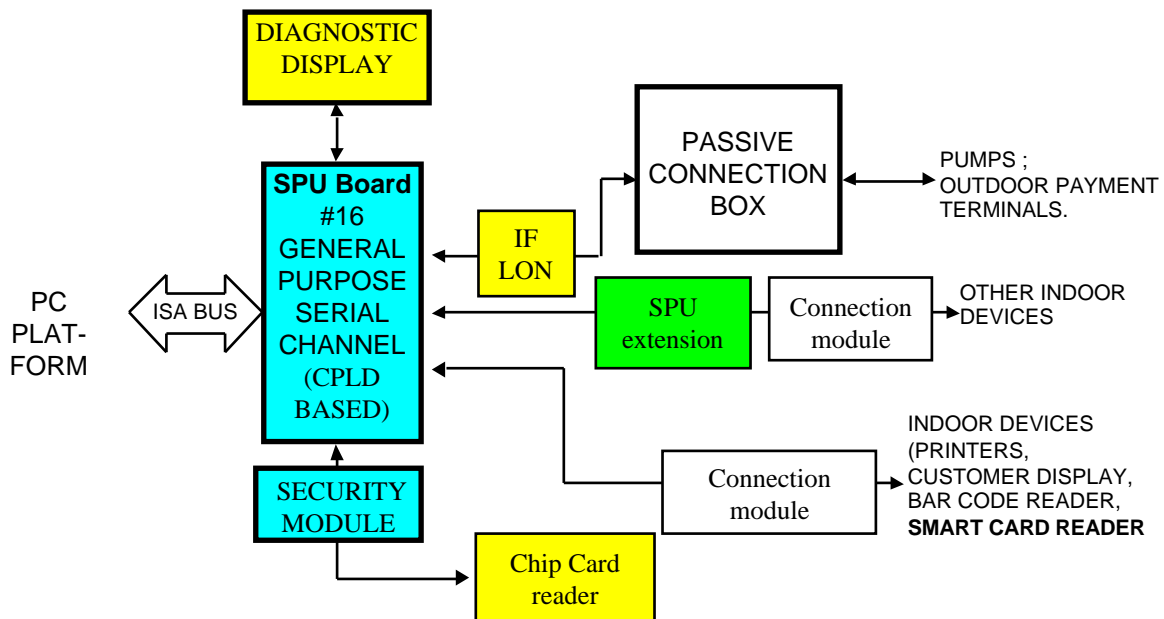
New single board Site Processor Unit SPU



New PumaHOST Architecture

Again, zooming on the system section which has been innovated:

Nen PumaHOST



The functionality of old system integrated in SPU module were:

- smart module Pump Logic Sequencer (PLS)
- direct control of power supply for data-safe capability
- security module embedded in CPLD device
- enlarging in number of controlled indoor devices

Added capabilities in new system obtained by SPU module are:

- display/keypad for hardware check-up
- chip card reader availability
- LON (Local Operating Network) interface - IFSF (International Forecourt Standard Forum) standard protocol that realises the interconnection between the forecourt devices

Design complexity can be measured through the size of the used CPLD device: for the new SPU the XILINX device XC9572 has been used. It is a chip in FastFlash technology, with 84 pins PLCC package and 1600 equivalent gates, with I/O delay till 7ns. Component usage percentage was of 95% and 99% of available pinout has been used as well.

The main reasons for choosing FastFLASH CPLD technology can be summarised with following ones:

- to reduce PCB space and complexity of 30% total
- to ensure intrinsic security (it is important to avoid possible clone of software)
- to have a chip package for through-hole mounting (socket+PLCC)
- to have lower cost
- to have easiness of programming

Other advantages of XC9500 series are:

- high number of programmable I/O
- JTAG interface embedded in the chip
- low cost

And more generally related to CPLD devices:

- easy to use development tool with EDA integrated

- VHDL language disposability

The new SPU makes the New PumaHOST features comparable with the competitors products ones. Moreover, some new PumaHOST characteristics are better than the same by competitors is, because the improved performances and the capability to answer to the customer's needs. An important PumaHOST feature is represented by its configurability. In fact, the SPU results to be configurable in an easy way thank the CPLD feature that allows to use the JTAG protocol. The JTAG allows changing the CPLD program, then the SPU characteristics, and then the overall PumaHOST features, directly on board.



New PumaHOST (on the left) and new complete system (on the right)



VII. Choices and rationale for the selected technologies and methodologies

Choice of design and fabrication methodologies

A primary selection for adequate device had been done considering a spread variety of products:

- **ASIC technology** would have allowed low price/unit but it needed higher NRE and greater number of unit/year, worsening ROI. Moreover it would be more difficult to implement the feature of system reconfigurability.
- **FPGA with high level of integration**, based on **SRAM technology**, would have allowed a higher level of integration but it was not competitive in costs and it had not characteristic of intrinsic security. Moreover it would have required an external programming ROM.
- **OTP technology** would have allowed lower component price/unit and it did not need NRE costs but it would not be possible reprogramming of chip
- **FastFLASH technology CPLD**, the one chosen, which represent a good compromise for Company requirements, particularly XC9500 XILINX series has not a high price. The chosen CPLD has a cost of 10 ECU and a cost reduction of 50% is foreseen in 1998. CPLD permits reprogramming of chip on board and has intrinsic security characteristics, because it is based on FastFLASH technology with In System Programming (ISP). XILINX™ has been chosen also because of the good reputation of the supplier. The Company had chance to contact it in the past.

At the date when the project started (October 1996) the economical comparison among evaluated technologies resulted in the following figures:

TECHNOLOGY	DESIGN COST (ECU)	MANUFACTURING FIXED COST (ECU)	CHIP COST (ECU)	EXTRA COST (ECU)	FINAL COST (ECU)
ASIC	65,000	40,000	15	0	65
Large FPGA	30,000	0	100	0	114
CPLD	20,000	0	11	26	46

where:

DESIGN COST	cost for development + cost for designing support equipment (not recurrent)
MANUFACTURING FIXED COST	cost for Foundry (not recurrent)
CHIP COST	cost per unit of the device (recurrent)
EXTRA COST	cost for those elements eventually not integrated into the device with new technology (not the same in ASIC, FPGA or CPLD) (recurrent)
FINAL COST	final unitary cost, computed considering depreciation on three years for the not recurrent costs and for a production volume of 700 pcs/year

Now things can be expected even better for FPGA and CPLD due to the consistent price reduction on the market for this kind of devices.

Choice of the development tools and methodologies

The development tool FOUNDATION from XILINX™ has been chosen due to the choice of the component. It allowed to carry out VHDL top-down design, functional and timing simulation and synthesis on the target component.

Choice of test methodologies

Device test had been performed in two different phases; first of all we used simulation tools included in development tool. By this way we realised functional and timing simulation of design. Second step had been the realisation of six prototypes for a global check of module functionality. Finally the Company performed test equipment for SPU testing and for final inspection of all the system new PumaHOST.

VIII. Expertise and experience of the Company

The Company expertise is relevant to:

Hardware design:

HW design with discrete off the shelf components, (logic, microprocessor based boards, logic interfaces, serial communication drivers (X25), cash and card readers, cash safes, outdoor and indoor equipment) where scale integration and severe environment are a working condition;

Software design:

Low-level software such as for Z80, 68HC11 and V25 microprocessors, high-level software in C++ (object oriented programming) for a multitude of operating systems and platforms (DOS, QNX, UNIX, WIN NT, LINUX); proprietary small-size operating systems.

Around 60 people work today in R&D and are helped by a group of consolidated third-party partner developers that cover about 30% of LOGITRON's R&D capacity.

LOGITRON is also expert in mechanical/electronic design suitable for strict safety requirement enclosures (EExd) and in hydraulic gasoline pump design. For the latter, LOGITRON in particular enjoys the expertise of their international partner Gilbarco Inc. that is the largest manufacturer of pumps and forecourt equipment in the world.

The Company is still held to technologies, which don't allow any improvement, but with considerable investments. Although the Company had the awareness of the possibility given by the new technology as CPLD, it wasn't capable to foresee the financial commitment and it did not had the necessary know-how to manage the development process.

Besides that the Company never used a component description language as the VHDL.

Three resources were allocated on the FUSE Application Experiment:

- Project leader technical and managerial background
- Technical manager technical and managerial background
- Designer technical and managerial background

IX. Workplan and rationale

The project has been structured on five steps of which, in the following description, are summarised the motivations and the activities accomplished :

<u>Steps</u>	<u>Description</u>
WP 1- Management	Planning, Design Flow with subcontractor, Schedule, Budget

WP 2- Training

- WP 2.1 LOGITRON and TTN jointly investigate CPLD design methodologies
- WP 2.2 To know the development systems and the designing/simulation software instruments.

WP 3 – Design

- WP 3.1 Definition of the integrated functions of the CPLD device
- WP 3.2 To design a CPLD device with the use of the development system
- WP 3.3 To use the instruments HW/SW of simulation CPLD project

WP 4 – Prototyping and Testing

- WP 4.1 Construction of a SPU module with CPLD
- WP 4.2 Acquisition of techniques that guarantee an exhaustive checking
- WP 4.3 Test of the SPU module with specially performed SW test routines

WP 5 – Dissemination

Creating information material

The AE, which scope was to integrate I/O functions with other ones in a CPLD, was globally realised respecting the budgeted costs.

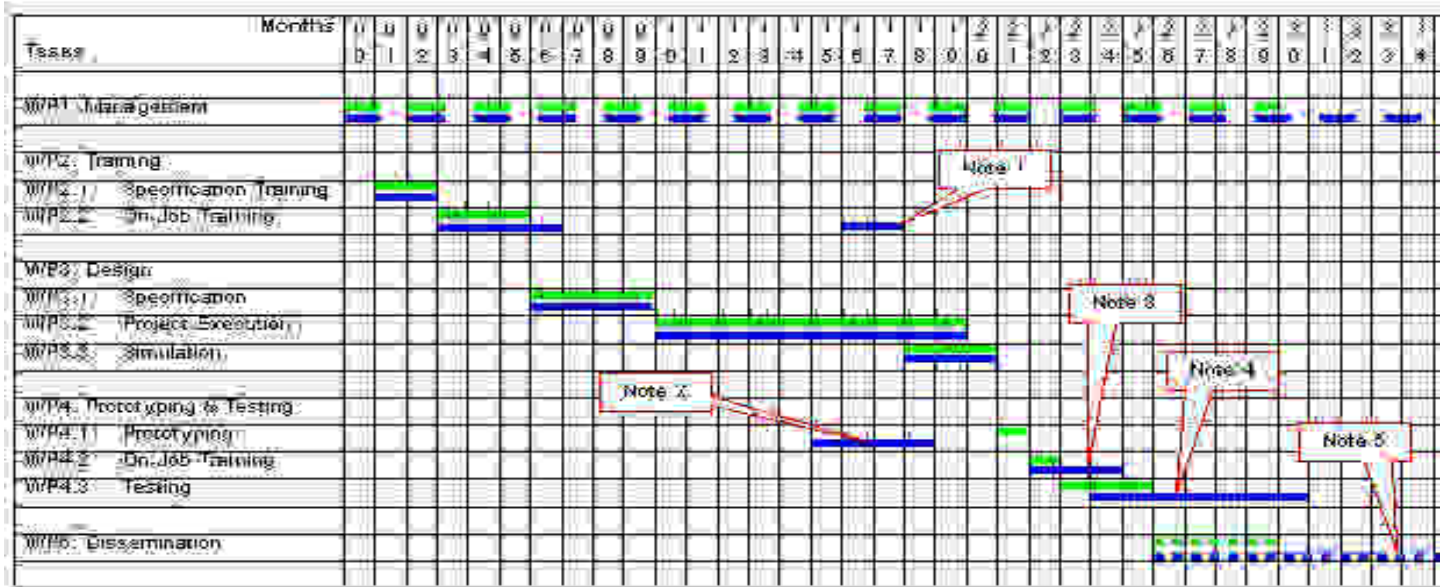
Knowledge transfer process

The training activity for two LOGITRON designers has been performed by subcontractor CESVIT during a cycle constituted by three courses:

- ✓ The first course dealt with the characteristics of programmable logic devices (PLD) and their differences with discrete logic and ASICs (held to the CESVIT headquarters)
- ✓ During the VHDL tutorial, the designers were trained in the VHSIC Hardware Description Language (held to the CESVIT headquarters)
- ✓ During the third course the designers were trained in the software tool they have to adopt in the project. Lessons were composed of two parts: in the former, theoretical, the teacher illustrated the software features, in the latter they got some practise compiling the VHDL code written in the preceding course; then they realised mixed VHDL/schematic projects and fitted them on several devices to highlight differences.

Some problem concerning the development system arose during the third course. The subcontractor participates on-job to problems resolution, with more time consumption than scheduled.

Picture below shows the original workplan (green lines) matching with the real workplan (blue lines). Deviations are highlighted as following:



Time schedule

- Note 1.* During the WP2.2 - On job training - the Company, according with the subcontractor, decided to move the final session of the tool course to the final part of the WP3.2 – Project execution – in order to develop all the tool features in depth. In fact, the course was based on a different device since the selected one was not available on that date. Unfortunately during the WP2.2 - On job training - phase some problems were found due to the non-stability of the product (many releases in few weeks): in fact the simulation results didn't match with the expected data.
- Note 2.* This was a very important step for LOGITRON: in fact the Company assumed the risk to fix the pin-out before the end of the CPLD project. This allowed the Company to start the SPU breadboard development in advance: some improvement was integrated in the CPLD and then in the SPU.
- Note 3.* Once activity explained in note 2 was successfully carried out, WP4.2 - On job training for Prototyping and Testing - took more time because of a problem related to the JTAG introduction. In the original plan the Company didn't foresee to use this feature.
- Note 4.* During the WP4.3 - Testing – LOGITRON found some problems related to the I/F downloading the CPLD program via JTAG. It needed the supplier presence in LOGITRON and much time was spent to research the defects. At the end, all the problems found their solution. One of the main problems was the programming loss in the chosen chip XC9500 XILINX . Totally the Company knowledge was increased.
- Note 5.* Dissemination is becoming one of the most significant parts of the whole project. In the original plan it took about 140 person hours. The amount is today about 160 person hours

LOGITRON and subcontractor had an intense interaction on three phases:

1. During the proposal documents preparation: the CESVIT – Microelectronics Centre experience about the FPGA and CPLD allowed LOGITRON to have all the information regarding the issues to take under control during the technology and component selection phase. The CESVIT –

Microelectronics Centre advised against the LOGITRON choose. As well, LOGITRON had extremely good indications regarding the project scheduling.

2. VHDL language course followed by the on job training phase, allowed LOGITRON to acquire appropriate design knowledge using programmable devices. The Company is now ready to reuse the knowledge in other projects
3. The on-job training was a focal point for the Company. Moreover, the subcontractor CESVIT – Microelectronics Centre experience was the key to solve all the problems related not only to the system but also to the development tools.

Effort and costs breakdown between the Company and the subcontractor can be summarised with the following table, where figures show budgeted and actual conditions, according to workplan refinement followed on going work:

	Labour (man-hours)				Costs (KECU)			
	LOGITRON		Subcontractor		LOGITRON		Subcontractor	
	Budgeted	Actual	Budgeted	Actual	Budgeted	Actual	Budgeted	Actual
Work Package 1	60	80			1.5	2		
Work Package 2	180	200	100	60	4.5	5	6	3,6
Work Package 3	560	400		40	14	10		2,4
Work Package 4	200	320	40	40	5	8	2,4	2,4
Work Package 5 (*)	140	160			3.5	4		
TOTAL	1140	1160	140	140	28.5	29	8,4	8,4

(*) Workpackage 5 - Dissemination - is relevant only to FUSE funded companies who have a proactive role within the whole FUSE action, collaborating with the subcontractor in spreading results of their technological innovation.

Companies who are considering adopting CPLD technology on their products shouldn't take this workpackage into account.

Any of the explained activity experienced LOGITRON. It is now autonomous in programmable device choice activity, in project planning activity and in developing the final solution.

X. Subcontractor information

The subcontractor choice was a key item both for the AE success and to achieve the foreseen knowledge transfer. This latter point was of particular care from LOGITRON since it aimed to become autonomous in the use of the CPLD devices.

At the end of this AE, LOGITRON can affirm that key-expertise to be required for the Subcontractor when developing a CPLD project are:

- relevant experience regarding the design and the use of CPLD (chosen subcontractor has been developing CPLD/FPGA projects for last 10 years);
- proven capability to follow a complete design flow, including prototyping, fabrication and test of digital systems as well as of boards mounting with CPLD/FPGA devices;
- accessibility and flexibility: the subcontractor has to be qualified to provide training and assistance to companies who do their first design in a new technology and it is also important that it gives availability for its own facilities (i.e. state of art tools);
- links with other suppliers

Evaluation of the subcontractor

The choice was carried out mainly taking into account that the potential subcontractor usually offered standard courses on VHDL design methodology and had good experience about "on job training" on the design and the use of Programmable Logic Devices design tool packages (Altera, Xilinx, etc.). Moreover it was "Vendor-independent" and this feature revealed to be extremely important while choosing CPLD device and tools. As a matter of fact the Subcontractor provided a fundamental support in choosing devices regarding both their performances and cost.

Moreover it is located in Florence and this made easy the collaboration activity with Logitron, whose site is located in Florence as well.

The subcontractor demonstrated to have a lot of links with different suppliers and distributors in Italy and Europe. This was a feature that LOGITRON reputed really useful to develop its project: in fact the Company had view on components and tools of the main different vendors and also strengthened its links with the local distributors.

Services provided by the subcontractor

Subcontractor supported Logitron's activity in two different phases of the project. In the first phase CESVIT allowed Company to have all essential information regarding the issues to control the technology selection. In the second phase our technicians received technical training which provided them the capability to describe the block functionality using VHDL language. Moreover, the subcontractor helped Company to solve the problems related both the system and the development tools.

In addition CESVIT, in quality of TTN, had taken care all the managerial aspect of the contract.

LOGITRON experienced that subcontractor was really flexible and was able to meet the various Company's needs both on technical and managerial aspects. Large part of the support was provided at the Company site.

The following table details effort and costs for those project activities where the subcontractor has been involved. Measure of the efficiency for interactions with the Company is also provided.

Subcontractor Services

Tasks	Person Hours	Cost (KECU)	Task Efficiency	Activity Description
1. Management				
1.1 Project management	0	0		
1.2 Reporting	0	0		
2. Training				
2.1 Specification Training	30	1,8	High	The FU was trained to produce specification applicable to the selected componer A general but comprehensive explanation regarding the SW tools was worked out
2.2 On Job Training	30	1,8	Medium	
3. Design				
3.1 Specification	0	0		
3.2 Project execution	40	2,4	High	All the VHDL SW tools and design techniques were explained in depth during a real design phase
3.3 Simulation	0	0		
4. Prototyping & Testing				
4.1 Prototyping	0	0		
4.2 On Job Training	40	2,4	Medium	The FPGA test methodologies and the JTAG technique were the OJT issues
4.3 Testing	0	0		
5. Dissemination				
5.1 Dissemination	0	0		
TOTAL	140	8,4		

< 0% High The efficiency is estimated task by task, calculating the ratio between the effort budgeted for a certain task and the actual effort spent on it. Figure resulting from this ratio quantifies, more than simply the performance, the quality of the knowledge transfer process between subcontractor and FU. "High" efficiency shows that the subcontractor / FU interaction worked well, with maximum yield

0 ÷ 20 % Medium "Medium" efficiency generally means that some problems, or sometimes only FU decision (i.e. to move a part of WP2.2 on job training to WP3.2), reduced the yield. Anyway total yield of the project can be assessed as positive, since CPLD development has been carried out with a little delay (about 1 month) and within budget.

> 20 % Low

Further information about subcontractor

- **Costs for AE support:** average hourly cost of 50-60 ECU
- **Subcontractors' resources allocated to the AE:**
 - 1 junior engineer,
 - 1 senior engineer,
 - 1 marketing and business analyst

The subcontractor activity covered 20,5% of the budget.
- **Contract and compliance:** Logitron implemented a project using FPGA technology and the subcontractor role was mainly devoted to provide training to the Company. There were no particular aspect to cover for what concerns IP either. For these reasons the contract was a simple one based on a standard offer describing the cost and time allocated to the work and then on the respective order. This kind of contract revealed to be really effective to guarantee the reaching of goals fixed at the start and it was well adequate with respect to the project characteristics.
CESVIT carried out activities within time and costs as reported in the offer/order, both relating with the technical and managerial aspect of the project.

XI. Barriers perceived by LOGITRON in the first use of the AE Technology

Although LOGITRON had perceived the necessity of a new approach in system rebuilding, it would have hardly chosen to follow this way without the useful help of an experienced support centre. It directed Company in development tool picking and supported it via an on-job training for on going work due to the new technology adoption, making available their expertise and their CPLD state-of-art tools.

Knowledge barriers

The Company has been working for years in a market where products are required with a very tight time to market. This is still the characteristic of the market where it is continuing to operate. The uncertainty on development time required by the adoption of a new technology strongly prevented them. Furthermore, without having a thorough knowledge of technology it would have been difficult to have the exact perception of budget and man/hour effort to be allocated for the project realisation.

Technology barriers

Technology barriers should be found in first user's lack of confidence in CPLD devices, in high level programming as well as in EDA design environment, tied to the absence of a suitable sensitivity for the whole process from design to prototyping, and from production to test.

Financial barriers

Financial barriers for this application experiment were not so high because of the limited investment required by new CPLD technology, mainly related to EDA tool purchase.

Perceived risks

The perceived risk was concerning the design complexity measured through the size of the CPLD device for the SPU application (the XILINX CX9572) that was expected to be useful for the purpose and the related uncertainties about the true capability to utilise the development system. Besides, Company was not able to foresee the effort to be applied in both design, production, selling and purchasing fields.

XII. Steps taken to overcome barriers and arrive at an improved product

LOGITRON was right time studying about the use of new technologies in the field of CPLD when it was contacted and visited by the TTN, thus learning about EU FUSE project. Compiling the proposal, the Company has been able to overcome most of the doubts concerning the results of the future AE. It scheduled the whole project and set up the work-plan in five different work-packages: management, training, design, prototyping and testing and dissemination activities to spread results of their application.

Most of knowledge barriers have been overcome thanks to the help of the TTN, also subcontractor for this project: its experience in this specific sector has allowed an exact definition of necessary design time, which had been proved to be coherent with real necessity.

Following the AE approval the Company has started training phase, co-ordinated and performed by CESVIT directly on the project, thus simplifying the learning curve for CPLD technology, VHDL design methodologies as well as for design tool.

XIII. Knowledge and experience acquired

Goals set by the Company at the very start of the AE were mainly related to technical and economical aspects of the project:

- to get a well working prototype, compliant with set specification
- to achieve target of board cost reduction
- to meet “time-to-market” requirements for the product
- to get an extensive knowledge of CPLD technology to replicate its application

Achievement of these goals was possible thanks to gaining huge experience in management field as well as in design and development field.

In the *management field* LOGITRON has experienced its own capability regarding feasibility study on CPLD applications and its planning, particularly the “time to design” knowledge.

The Company followed a method in order to schedule all the activities and to keep them under control, realising then a continuous check during the project execution activities.

The Company had not used this methodology before the AE.

At the AE beginning, LOGITRON was not sure of the ratio effort vs. result. In fact, the Company was not able to foresee the effort due to the technology introduction to be applied in design, production, selling and purchasing fields. Also thanks to the subcontractor support, LOGITRON reached all the work plan milestones, reaching also the goal of a prompt time to market. This successful experience made the Company more confident about microelectronics solutions and their management.

Another very important aspect for managerial issues was about how to manage the relation between the Company and the subcontractor. LOGITRON was accustomed to have subcontractors but they generally were simply suppliers.

The Company was instead called to choose a subcontractor able to realise any project issues and, moreover, able to interact with LOGITRON in order to improve its own learning curve.

This aspect was very important for the Company, since it is now able to replicate acquired knowledge onto other projects.

In *technical field* LOGITRON experienced some troubles with bugs of chosen development tool. This experience was very important for the Company also considering that during the pre-feasibility stage it had been discouraged by the subcontractor in adopting tools not already sufficiently checked by the market.

Most of the difficulties carried out during ongoing work have been tied with the weakness of development tool. Some examples are the following ones:

- Dissimilarity between chip simulation and real working. One of the most relevant anomalous conditions was that of having flip flop with pre-set correctly working on the CPLD device but their condition was not shown during the simulation phase
- need of constant upgrade for development tool (also three times a month)
- development software incompatibility with WINDOWS95
- Difficulty in programming chosen chip. It had frequently losses of program
- XILINX hardware key incompatibility with any device mapped out on the same parallel port

As well, new test methodologies were successfully introduced by LOGITRON in the manufacturing process in advance to the knowledge and experiences expected at the beginning. During the production test CPLD “on-board-programming” using the JTAG protocol was introduced. The Company found this methodology very useful, reducing programming times and all the problems related to the CPLD program releases management.

It has to be noted that the Company was stimulated on JTAG techniques also thanks to its participation in the ED&TC Conference in Paris.

The Company attended the Conference under TTN suggestion and exchange of experience with other users as well as visiting stands on JTAG tools pushed them definitively towards this new methodology.

XIV. Lesson learned

Managerial Lessons

Planning and Controlling a Project: The Company warmly advise to introduce project management methodologies as useful instrument to control the project itself. Many deliverables of the AE were relevant to Project Review meeting outputs and project management updates (budget and schedule). These deliverable constitute the measure of managerial skill achieved by LOGITRON

Technical Lessons

Problems with EDA environment: LOGITRON learned to take under control the development tools efficiency: in fact the work plan delay, although just a month, was due to the tools problems as differences between the simulation results and the real function results or the high releases numbers (one every three months).

Choice of CPLD device: the Company learned which are the key-points to be taken into account to choose a suitable CPLD device:

- Type of technology for CPLD
- Comparison between logic required by the project and logic available on the chip concerning:
 - ✓ Amount of internal logic
 - ✓ Number of I/O
- Component market features like cost and availability within short times (LOGITRON hardly suffers time-to-market constraints)

CPLD design with joint solution VHDL-schematic entry: the Company came from a traditional design methodology and learned how to profitably exploit VHDL top-down design methodology using VHDL descriptions at RTL level, joint with a top view with schematics.

This mixed method is recommended to Companies coming from same technical background as Logitron is to take all the benefits of the new design techniques, maintaining readability of schematics, which designers are more used to.

Hence total Company's design efficiency increased.

XV. Resulting product, its industrialisation and internal replication

The XILINX™ is releasing now the newest M1 SW release supporting all the problems found by the Company during the development phases on the XC9500 family.

Besides, thanks to the device success, its cost is now reduced of 50%. In fact, 10 ECU was the foreseen price, 5 ECU is the actual price. Two distributors present in the Tuscany region supply the device. Hence all the main concerns of the Company to bring to prototype to the market (reliable tool and low cost devices) are now solved and the **SPU industrialisation is today successfully realised. First products have been already sold.**

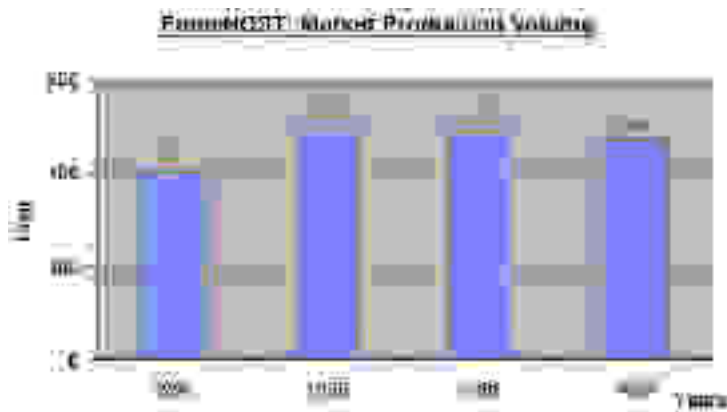
Industrialisation activity took 3 months with costs due only to internal activities. Additional persondays spent to have a product suitable for production were 19, while other 20 persondays were necessary to bring the final product on the market.

All these reasons allows the Company to follow with success the new way, that is the integration of the logic circuitry used in other of its own product into programmable devices, reaching the double goal of cost saving and higher reliability.

LOGITRON already performed an **internal replication** in the use of CPLD technology by re-engineering a board using the XC9572 device, the same used in the AE. The new design concerns **an automation control used in a knitting machine** that reaches many goals like higher reliability, easy re-programming capability to follow the market needs (using JTAG) and, least but not last, the cost saving goal.

XVI. Economic Impact and improvement in competitive position

The Company boasts a leader position in Italy, while the PumaHOST is currently suffering its product maturity: in fact both domestic and international market are declining. Figures in table show the decrease.

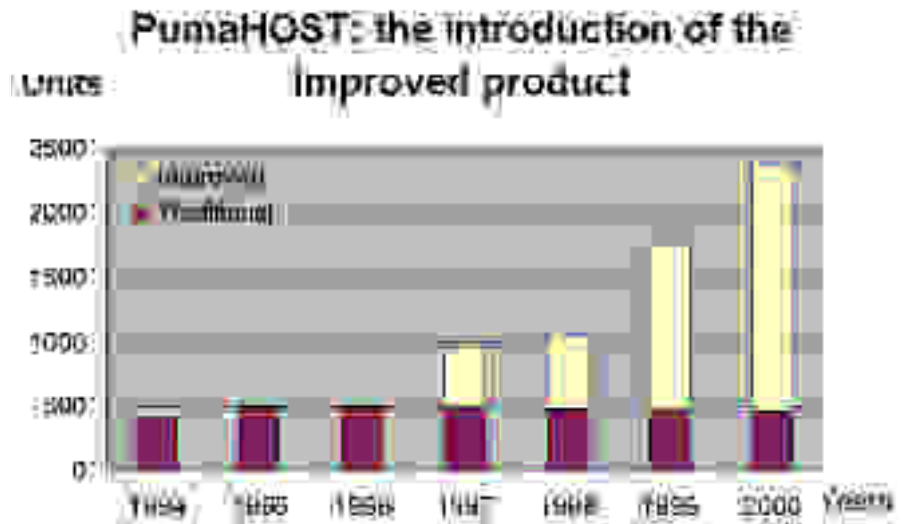


New PumaHOST cover the features gap existing with competitor's C-store capability products. The improvement of the new PumaHOST, mainly cost reduction, increased reliability and serviceability, permits LOGITRON to enforce its competitive position on European markets where the share of LOGITRON is still low and to acquire East European

markets, where the growth is foreseen to be very high. Other markets as Asia and Africa are foreseen to be interesting.

The Application Experiment ended in May 1997 and in three months only the Company has already improved the product sales of about 48%. This remarkable increase is also due to a new profitable market scenario, which arose recently.

In conjunction with the reduced cost, improved characteristics and reduced time to market of the product, oil distributors boosted automatic fuel dispensing service by reducing of 3% oil cost if self serviced. This caused the positive sales explosion for LOGITRON products, mainly for PumaHOST system.



Calculation for Return Of Investment (ROI) should take in account the following items:

- **Software investments:** the comparison between old and new PumaHOST is at product level, where large investments have been allocated and the product restyling is still on going as concerns the development of a new software. Software development is the task which has been requiring higher efforts and costs and this task is supposed to be ended within 1998. we consider total investments sustained by LOGITRON on the whole product (including Software), the payback period is expected to be within 4-5 years.
- **Hardware investments:** the development of a new Hardware for PumaHOST can be split into:
 - HW for Site Processor Unit (target of the Application Experiment), where the old boards GPPH and PLS (see old PumaHOST Architecture picture) were replaced by the new SPU with an additional external passive module. Comparing these two hardware sets, the Company is saving 21% on manufacturing costs for this set and 3% of total PumaHOST manufacturing costs with the new hardware version. CPLD re-programming can be estimated as accounting for 6% additional turnover relevant to the new PumaHOST. Thanks to new product features forecast world-wide sales for next years can be reasonably assumed to be as shown in table above: roughly 1000 units in 1998, about 1700 units in 1999 and more than 2300 units in 2000. This means a total cost saving during next years of:

	1998	1999	2000
Total cost saving addressable to CPLD investment	22.5 KECU	38.25 KECU	51.75 KECU

Assuming

- a FUSE funded investment of 41 KECU for this project
- 18 KECU average yearly cost saving due to this part
- 5 years of average product lifetime

the FUSE investment can be recovered on a with a ROI (total incremental profit on product lifetime/initial investment) of 220% with a payback period of 1.5 years.

- Additional HW redesign for the system out of the SPU board required additional investments estimated mainly as NRD (Non Recurrent design costs) and whose amount was at least equal to the FUSE funded investment.

XVII. Target for dissemination

The AE object **was to integrate and to manage a large number of I/O functions using a CPLD device**. The AE successful demonstrates that it was possible and convenient to do it. Other benefits was reached from the re-configurability capability of the device. Moreover, it was possible to include other features not related to the I/O functions in the same device. This is a real general-purpose application, whose very general features (production cost reduction, size reduction, performance improvements, etc.) make the AE a very interesting application for many sectors, especially for those companies with characteristics similar to the Logitron ones. The sectors indicates for dissemination are:

<u>Sectors</u>	<u>ProdCom</u>	<u>Rationale</u>
<u>Precision Instruments</u> for measuring, testing, etc	3320	A high number of application needs I/O management and re-configurability features. The CLPD technology could be able to solve it.
<u>Industrial Process Control Equipment</u>	3330	Where a large number of I/O are requested. The CLPD technology could be useful to re-configure the I/O device features.
<u>Office Machinery</u>	3001	The CPLD could be used to manage the I/O activities relieving this hard task to other parts of the system. The I/O characteristics should be changed using the re-configurability capability of the device.
<u>Office Machinery</u>	3002	
<u>Computers and Other information Processing Equipment</u>		
<u>Manufacturing Machines</u>		
<u>Mechanical</u>	2940	Managing a large number of I/O allows a detailed and accurate status control of the whole system, leading to have a more stable and precise one. The CLPD could be useful to manage this task.
	2951	
<u>Textile</u>	2954	
<u>Transportation Product</u>		
<u>Transportation Equipment</u>	3550	It is possible to perform standard I/F protocols management on the CPLD, making it useful to be used in fields where standard I/F are used to manage the whole system.
<u>Electronic Components</u>		
<u>Telegraph and Telephone apparatus</u>	3220	On telecommunication fixed system the high number of I/O ports could be managed by a CPLD.

Besides, all the Companies more specifically involved in **Point of Sales management** should be interested to acquire knowledge by the LOGITRON AE.

In order to give a complete stated of the target audience, following is reported a table showing the Company profile:

Management:	With a good general knowledge level and ready to keep up with advanced technologies
Starting technology:	μP, digital discrete components
Applications:	Tools & Machinery, Pumps and Compressor
Development Methodology:	PCB, μC, analogue and digital technique
Barriers:	The uncertainty on development time to make Company confident with new technology had brought mistrust in approach. Furthermore, without having a thorough knowledge of technology it would have been difficult for the management to have the exact perception of budget price and man/hour effort for the project realisation.
Company Size:	300
Company turnover:	38 MECU

LOGITRON already co-operated actively in TTN dissemination activities and it will proceed on this way because profitable links with TTN match Company's market strategies to promote the new PumaHOST product.