Fuse Demonstrator Document

AE 25777

A generic actuator for Electro-luminescent Foils allows the integrated backlighting for keyboards and front-panels.

Abstract description

ACL TechnoSwitch is a Belgian SME, employing 19 people, founded in 1985. Its business is the design, manufacturing and sales of membrane switch front-panels and keyboards. Its products have virtually no electronic content, so the company basically is a non-microelectronics company. It is selling its products to some 50 different Original Equipment Manufacturers.

The objectives of the AE was to improve its front-panel technology by integrating Electro-luminescent foils in the front-panels and by developing the required electronics, to actuate the Electro-luminescent foils.

The existing products are multi-layered front-panels with 4 to 8 layers, including membrane switches, interconnect layers (flexible printed circuit boards) and Electro-luminescent foils.

The technology chosen was Printed Circuit Board, with discrete components. An important result of the project was the development of design guidelines, allowing its customers to integrate the controller-actuator in their own product. For high volume projects, the integration of the actuator-controller in a dedicated integrated circuit will be an economic solution.

The development of the controller-actuator, and the design guidelines, was important to broaden the customer base of front-panels, and keyboards, with integrated Electro-luminescent foils.

The development started November 22nd '97 and ended November 20th 98, a total duration of 12 months. The total duration was according to the original plan. The project was funded by FUSE, for a total of 52.2 kECU.

The payback period of the investment is calculated to 24 months, taking only into account additional sales of electro-luminescent displays and controller-actuators in the keyboards and front-panels. The return-on-investment is estimated at 239% over a period of 5 years. The payback period will be reduced to 20 and to 16 months, by targeting new market niches, such as advertising, road signs, and control and dashboard displays for cars, boats and trains.

The most important lesson was that the company could gain a lot by working together with subcontractors. The company's culture before this project was to do all developments in house. This project also has allowed the company strengthening its management and marketing. Before the company was mainly driven by technical expertise.

Keywords:

Non-microelectronics, Controller-Actuator, Front-panels, Keyboards, Electro-luminescent panels, Membrane switches, Display panels, Inverters

PRODCOM: 3210

SIGNATURE: 7 aaa bbb ccc 0 1 1 32 B

1. Company name and address

ACL TechnoSwitch bvba
Nieuwe Baan 70
9111 St.-Niklaas (Belsele)
Belgium

Contact: Dirk Casteleyn
Tel.: +32-3-722.03.03
Fax.: +32-3-722.03.84
Email: click@quad-ind.comWeb: www.quad-ind.com

2. Company size.

Number of Employees: 19. None of the personnel members had any experience in the design, development or manufacture of microelectronics.

	Company Turnover	Product Turnover	Contribution of product to companies turnover
1996	650 kEUR	2.5 kEUR	0.4%
1997	800 kEUR	12.5 kEUR	1.6%
1998	1050 kEUR	25 kEUR	2.4%

From the beginning, 1 employee was allocated to the project:

Mr. G. Claeys: general manager and responsible for the project. Mr. Claeys founded the company and was in charge of all technical developments, but also for general management, production and sales.

During the project, Mr. Claeys decided to restructure. 2 People joined the company and strengthened the development team:

1. Mr. D. Casteleyn: joined as sales and marketing manager.
2. Mr. D. van Landeghem is a technician with a basic education in electronics and with prior experience in audio electronics. He joined the research & development group and is in charge for the design of microelectronics.

3. Company business description.

· ACL TechnoSwitch bvba (ACL) is a small SME specialised in the engineering, design, manufacturing and sales of membrane switch panels.
· The main products are Front-panels and Keyboards.
· ACL integrates plastic or metal dome switches, LED's, Displays (text or graphics) and background illumination in their front-panels and keyboard.

Front-panels and keyboards are manufactured for and sold to original equipment manufacturers, currently mainly (over 60%) in Belgium.

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

For the membrane-switch front-panels and keyboards 62% of the products in the product-line are targeted for the Belgium OEM market. 38% of the products is exported in the European Community, mainly to the Netherlands and Germany.

The total annual turnover in front-panels and keyboards in Belgium is approximately 8.7 MEUR. ACL has a market share of about 8 %:

Turnover of ACL, only Belgian market share:

1996	650 kEUR
1997	800 kEUR
1998	1050 kEUR

Contribution to turnover in 1998:

Keyboards, front-panels including membrane switches	74%
Front panels	20%
Others	4%
EL Lamps	2%

In 1996, there were the first indications that an interesting market was developing for the use of Electro-luminescent Lamps. This market niche was expected to grow considerably. ACL investigated possible future business opportunities in this market niches, and decided that it wanted to establish a solid market position in this segment. There was an important overlap with the technologies used in the front-panels and keyboards, and the front-panels and keyboard business would benefit from the know-how acquired in the domain of Electro-luminescent lamps.

The major competitors on the Belgian market are:

Name	**Country**	**Relative Size to ACL**
VELLEMAN SWITCH	Belgium	3x
METAGRA	Belgium	2x
MORS-APEM BELGIUM	France	2x

Together with its 3 main competitors, ACL is covering 80% of the market share. Metagra and ACL are both using metal-dome membrane switches. Velleman is mainly using plastic-dome switches, that are cheaper, but that have limitation for industrial design.

For Mors-Apem, membrane switches are a small business unit, in a big concern. Membrane switches are not their core business. They have a much wider customer-base, because they are also selling standard switch technologies. Their weakness, compared to ACL, is that they do not have a local technical development centre in the Belgian market.

Metagra is not including Electro-luminescent foils in its keyboards and front-panels. ACL is the only Belgian manufacturer with metal-dome membrane switches, and integrated Electro-luminescent foils. The integrated Electro-luminescent foils allow lighting of the front-panel switches, without requiring the use of light-emitting diodes (LED's) or lamps for

backlighting. This results in considerable saving in weight, volume and power-consumption. At the same time cost for mechanical mounting disappears.

The technology is opening new market segments for the membrane-switch front-panels: navigation equipment for boats and trains, portable data-entry equipment for gas and electricity distribution, etc.

A very important market opening is the market for front-foils, without integrated switches: dashboard displays for the car industry, instrumentation panels, emergency lighting and emergency signs, etc. These niches are completely new and represent an important business opportunity.

The strength of ACL was that it could adapt very well to specific demands of its customer base. Its weakness, specifically regarding the displays, front-panels, and keyboards with integrated electro-luminescent foils, was that it could not provide controller-actuators to its customers, nor was it able to provide detailed design guidelines to those customers, that wanted to include the controller-actuator in their own product.

Sales of keyboards and front-panels with integrated electro-luminescent foils evolved from 2.5 k€ in '96, 12.5 k€ in '97, and 25 k€ in '98.

5. Product to be improved and its industrial sectors.

Front-panels and keyboards with integrated membrane switches are built in several layers, each with very specific mechanical, chemical and electrical characteristics. Each application calls for a specific combination of such layers and an integration of LED's and backlighting for feedback to the user and for use in the dark. Front-panels and keyboards are produced using printing techniques. As such the various materials are applied to the ground layer in 1 or more steps per layer.

These front-panels and keyboards are included by original equipment manufacturers into their own equipment.

The parameters to be improved is the ability to provide actuator-controllers to some of its customers, or to provide the know-how on how to integrate the controller-actuators in their products, to the other customers. Being able to do this, a market increase by a factor of 10 will be possible, by the end of 2001. This increase is expected addressing the existing customer base only. There are additional opportunities to target completely new market niches.

Overview of existing products.

6. Description of the technical product improvements.

ACL aims to integrate Electro-luminescence in the front panels. For this purpose know-how is used form the University in Gent to optimise this integration. The resulting EL-membrane switches would be unique in their mode of integration and their use is only justified in a long-term innovative strategy of a small producer of membrane switches, able to combine flexibility in design and service with the ambition to deliver top quality, today and in the future.

The development consists of 2 parts: the integration of the electroluminescent foils and the development of a controller.

a. The electro-luminescent foils.

EL foils are a complex combination of layered materials. Each of the materials is used for either is mechanical, electrical and/or chemical characteristics and behaviour.

A typical EL-foil is composed of 5 main layers:

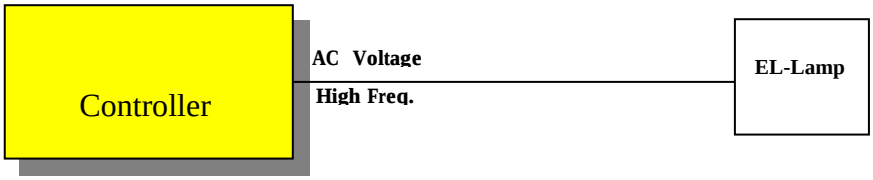
* Transparent polyester layer for the protection against environmental influences.
* ITO: conduction towards the phosphor-layer. (Indium-Tin Oxide an alloy of In_2O_3 and SnO_2)
* Phosphor + polymer: The phosphor is mixed with polymer to realise the required spread of phosphor for each application.
* Ceramic: the dielectric medium for the electromagnetic field of the component.
* Silver: back-electrode, lower conduction towards the phosphor.

The product improvements can be summarised as follows:

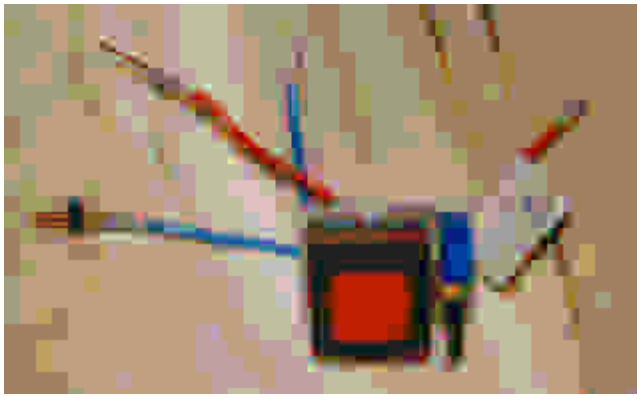
1. The integrated Electro-luminescent foils allow lighting of the front-panel switches, without requiring the use of light-emitting diodes (LED's) or lamps for backlighting. This results in considerable saving in weight, volume and power-consumption.
2. At the same time cost for mechanical mounting disappears.

b. The controller.

For the control of the EL foils dedicated controllers are available on the market.



There are some modules with limited application capabilities, available in the market, see pictures below:



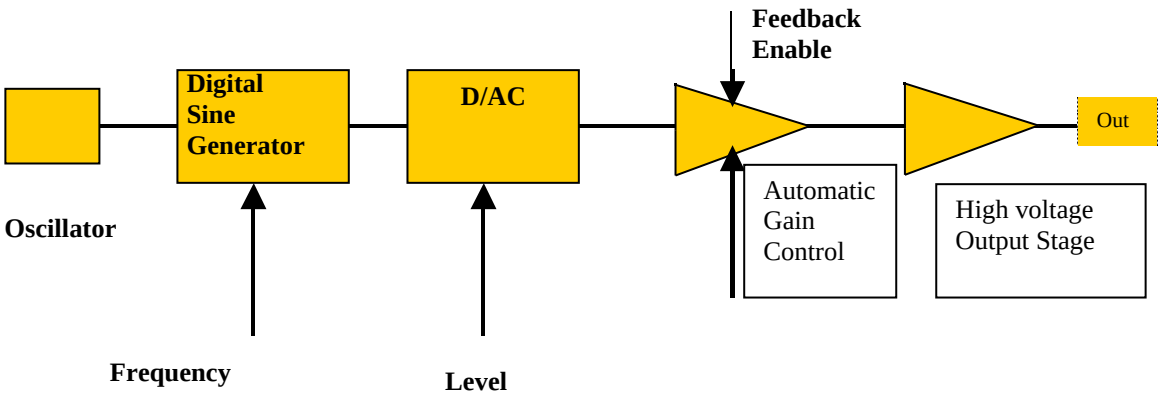
Recently some ICs (SMD) became available for integration in controller-actuators. These ICs allow for a straightforward control of the EL-foils with all parameters kept constant over their lifetime. The area of the foils that can be driven by these ICs is limited, the ASICs being applied mainly in the watch-industry, in pagers and GSM phones. These existing ICs are not capable of driving the Electro-Luminescent Foils with an area, needed for front-panels and keyboards.

The improved controller-actuator should be able to actuate the Electro-luminescent foils with different voltages, different frequencies, and it should be possible to adapt their output power (2W - 50W). Voltages (50V - 450V) and frequencies (50Hz - 2000 Hz) define the colour, intensity and lifetime of the EL-foils, and need to be tuned to the application. This requires redesign and optimisation for each customer, leading to high NRE cost. The core of the controller-actuator should be standardised for different applications.

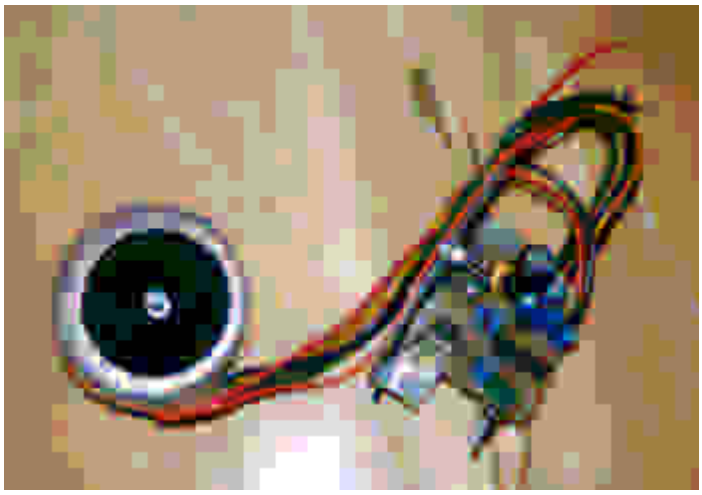
The controller-actuator basically consists of a programmable digital sine-wave generator, and gain-controlled digital-to-analog convertor, an automatic gain control, to provide brightness

stability over the life-time of the product, and a high-voltage gain-stage, to directly drive the electro-luminescent foils.

The block-diagram of the controller, and a photograph of the complete controller-actuator are shown here below:



The frequency is set by dip-switches, and influences mainly the colour of the display.
The level is set by a potentio-meter, and defines the intensity if the display.
The Feedback enable, combined with the Automatic Gain Control, can provide correction for the changes in brightness, over the life-time of the display. Input comes from a light-sensitive diode.



Pre-production prototype of controller-actuator.

Since the electrical specification of the controller depends very much on the details of the EL-foils to be driven, a design handbook has been developed, and 2 different controllers have been implemented, targeting different applications in size of the EL-foils that can be driven.

7. Choices and rational for the selected technologies, tools and methodologies.

EL technology has been selected because it can easily be integrated with the membrane-switch technology. It allows a significant reduction in weight, volume and power consumption, compared to other ways of backlighting. Moreover, it allows a significant reduction in manufacturing and assembly cost.

For the drafting of the specification of the controller-actuator, it has been decided to make a development controller-actuator, where all relevant parameters could be easily set. The

stimulation voltage could be varied from 50V to 500V, the frequency from DC to a few kHz and the output power from 2W to 100W. This equipment has been used to evaluate different EL foils, from different manufacturers, and with different chemical composition. The effect upon colour, brightness and lifetime could be assessed. From these measurements, it has been possible to derive a final specification for the controller-actuator. The development controller-actuator can be used by OEM to explore the effects of frequency and voltage upon the colour and brightness of their front-panel.

Starting from the specification, different implementations of the controller-actuator have been assessed to arrive at a "design guideline manual". This handbook explains to OEM how to integrate the controller-actuator for the front-panel EL into their electronics. In many cases, OEM prefer to include the controller-actuator in their own product, rather than include an separate physical controller, procured together with the front-panel.

This manual has been used to manufacture two prototype controller-actuators optimised for different keyboards with integrated Electro-luminescent foils and integrated membrane switches. These units have been developed for specific front-panels. The implementation technology of choice was printed-circuit board, using discrete components, addressing low volume customers, and proving feasibility.

The feasibility of integrating the controller-actuator in an ASIC has been assessed by IMEC. An area estimation has been done, and Europractice can manufacture the controller for 2.93 € apiece, in volumes of 10k units per year. Initiating the design of the ASIC controller-actuator will depend upon market demand. In the mean time, the possibility of integration can be used in the marketing strategy.

The implementation technology in the end, will be decided by the customer. Either he will use a dedicated controller, using printed circuit boar, or he can integrate the actuator-controller in his own product. Several implementation technologies will be open, ranging from PCB, SMT down to a dedicated ASIC.

It was decided to subcontract the work to a company, experienced in the design in electronics, since the necessary know-how was not available within the company. The work was closely monitored and guided by Mr. Claeys who was in charge of the integration of the EL-foils in the membrane-switch front-panels.

The layout of the PCB has been done by ACL using LAYO from Baas Electronics, a Dutch company (www.baas.nl). It is a CAD tool running on PC, available under the Windows OS. The manufacturing of the PCB was subcontracted to a specialised company. Mounting and soldering of the prototypes was done manually by ACL For volume series, this activity will be subcontracted.

8. Expertise and experience in microelectronics of the company and staff allocated to the project.

ACL is producer of mainly front-panels and membrane switch panels for the electronic sector. Technologies used are mainly screen-printing, and mechanical operations. Several electronic components are used in the keyboards. From this point of view ACL is acquainted with electronics, but ACL does not possess the appropriate know-how and technical skills to

investigate, design and develop microelectronic circuits. ACL should be regarded as a non-microelectronics company.

In the past, all technical developments were done within the company. ACL did not have the culture of subcontracting design or development to third parties. ACL was involved in joint research projects with the engineering department of the University of Gent. This research was related to the reliability and long-term stability of the Electro-luminescent foils.

The project was monitored by the technical manager of the company, who had no education or experience in electronics. An electronic technician has been hired by the company, at the end of the project, to support the know-how acquired to the customer base.

For this ACL integrated the know-how and expertise of **B&A Electronics from St-Truiden and Cimmod NV from Dentergem** in the process.

- B&A assisted with the developing, design, calculations, drawings of the controller-actuator to work to the final product, the prototype actuator.
- Cimmod NV stood for the training and the co-ordination of some stages in the project and market research. Cimmod also assisted in project management.

9. Workplan and rationale.

Gantt Chart with effort of ACL in working days.

Months	1	2	3	4	5	6	7	8	9	10	11	12
1.Technical management	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
	3	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
2.Training effort actuator		*10*	*10*									
		8	**5**									
3.Training effort EL		*10*	*10*									
		10	**10**									
4. Specification				*10*	*10*							
				10	**5**	**5**						
5.Integration of EL in process:												
5.1 Design					*7.5*	*7.5*						
				7	**15**							
5.2 Fabrication						*7.5*	*7.5*	*7.5*	*7.5*			
					10	**10**	**10**	**10**				
5.3 Test									*7.5*	*7.5*		
								7.5	**7.5**			
6. Actuator Prototype:												
6.1 Design						*5*	*5*					
							12	**12**				
6.2 Fabrication							*6.7*	*6.7*	*6.7*			
								3	**3**	**4**		
6.3 Test									*5*	*5*		
										7.5	**7.5**	
7. Feasibility ASIC												
											3	
8. Dissemination report												*10*
												10

Total	3	23	23	13	20.5	23	22.2	17.2	29.7	15.5	8	13
	3	**21**	**18**	**20**	**33**	**18**	**25**	**35.5**	**13.5**	**14.5**	**13.5**	**13**

Gantt Chart: Shaded fields are actual, un-shaded italic fields were planned.
There was no major deviation from the planned workplan.

- Tasks 1, 2,3, in assistance of both subcontractors Cimmod and B&A
- Task 6.1. in assistance of B&A
- Task 8 in assistance of Cimmod

Task	**Labour ACL in days**	**Cost B&A**	**Cost Cimmod**
1. Technical management	31+5		1.24 kECU
2. Training effort EL	8+5	1.24 kECU	1.24 kECU
3. Training effort actuator	15+5		1.24 kECU
4. Specification	20		
5. Design EL foils	22		
6. Fabrication EL foils	40		
7. Test EL foils	15		
8. Design Actuator	24	2.48 kECU	
9. Fabrication Actuator	10	2.48 kECU	
10. Test Actuator	15	744 ECU	
11. Feasibility ASIC	3	496 ECU	
12. Dissemination	5+5		1.40 kECU

Task description and responsibilities:

Tasks 2-3: Training was given on project management and on product marketing by Cimmod. B&A Electronics provided training in the development of controller-actuators.

Tasks 4-7: The specification, design, fabrication and test of the front-panels with integrated EL-foils was done in the Lab of ACL Claeys, since this involved applying its existing experience in screen-printing and manufacturing. A lot of effort went in the analysis of the foils, optimising the reproducibility of the manufacturing process and lifetime tests.

Tasks 8-10: The design, fabrication and test of the controller-actuator have been done mainly by ACL. The subcontractor assisted in the phase of exploration of the design alternatives, the architectural analysis, in the electronic design and the writing of the design guideline handbook. The layout to manufacture a proper controller-actuator was done by ACL, using the Layo tool of Baas Electronics

Task 11: The feasibility of integrating the controller in ASIC has been assessed by IMEC, at no cost.

The project evolved within the planned timing and budget. The role of ACL has been addressing all issues relating to the Electro-luminescent foils, including characterisation, design and test. All electronic design has been subcontracted to B&A electronics, ACL again has been in charge of the manufacturing, assembly and test of the printed circuit board.

The knowledge transfer has been realised in the form of design guidelines. These guidelines outline how to optimise the controller-actuator to each specific display or keyboard. ACL has hired a technician to disseminate this know-how to its customers.

10. Subcontractors information.

Since ACL was a non-microelectronics company, a subcontractor able to offer turnkey solutions was needed, specialised in dealing with companies having little expertise in electronics. The subcontractors task would be to write design guidelines, rather than to deliver a hardware prototype, so writing skill were very important.

· **B&A Electronics** is an Engineering and Consulting company specialised in the study, design and development of electronic devices and EMC calculations.
Address: dÓyestraat 13
3800 St-Truiden
Belgium
Tel. +32-11-69-22-14

B&A assisted ACL mainly in the first phases of the project, explored design alternatives, did the architectural analysis, the electronic design and made the final documentation and drawings to develop and manufacture a proper controller-actuator. Since B&A had no prior experience with Electro-luminescent foils, a close collaboration with ACL was required. The contractual basis was no cure, no pay, fixed cost contract. All deliverables would become property of ACL.

· **Cimmod** is a consulting company in assisting companies with training and co-ordination of whole micro-electronic projects. It assisted ACL mainly in co-ordination with the assistance of B&A.

Address: Markegemsesteenweg 76
8720 Dentergem
Belgium
Tel. +32-51-63-32-75

ACL was a company that was thriving mainly on its technical competence. To allow the company to grow, and to enter new market segments, Mr. Claeys, the general manager, has decided to strengthen the management of the company. The relationship with Cimmod has evolved into a crucial participation, where Cimmod now is strengthening ACL TechnoSwitch in daily management, focusing upon marketing, financial management and strategy.

There haven't been any problems with nor project delays due to the subcontractors.

11. Barriers perceived by the company in the first use of the AE technology.

Technological barrier:
ACL did not possess the knowledge regarding this type of controller-actuator, and did not have the in-house knowledge to develop electronics of these specific types.
Marketing barrier:
EL lamps are opening new markets and are still in complete development and evolution. ACL is aware of this and had many questions:

- How is the market going to develop, expand?
- Will the producers of chemicals (phosphors,) continue to invest into those markets?
- Is it up to ACL to invest in an controller-actuator?

Cultural Barrier:

In the past, all technical developments were done within the company. ACL did not have the culture of subcontracting design or development to third parties.

Operational barriers:

- ACL had to work together with sub-contractors without having the advantage of having their own electronic-engineer to co-ordinate and communicate the technical implications regarding the project in the company.
- What type of controller-actuator needed to be developed?

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

Cultural and Technological Barriers:

ACL had been in contact with technology consultants, that had helped them with the management of a research project with the University of Gent, in the framework a project, funded by the IWT, an organisation funded by the Flemish government.

Through the contacts with the technology consultants, and through the activities of the Flemish TTN, management was persuaded to start a FUSE project involving the co-operation with an electronic subcontractor.

A FUSE proposal has been prepared. Approval of this proposal, after review by external, independent experts, has convinced the general manager that it was a wise thing to do, and to start the project.

Marketing barrier:

The marketing issues originally were addressed by the technology consultant. During the project, the general manager decided to strengthen the company, mainly on the level of marketing, and it was decided that the technology consultant would participate financially in the company, and would become a partner, rather than a subcontractor.

Operational barriers:

ACL has hired an electronic technician, at the end of the project, to disseminate and support the results of the project to its customer base.

13. Knowledge and experience acquired.

ACL learned a lot during the complete project:

- ACL learned how to optimise controller-actuators to each specific application. An electronic technician was hired to do this. ACL acquired the capability of transferring this know-how to its customers. It does not need additional external help to achieve this.

- It has learned how to control colour, brightness, and how to prevent changes over the lifetime of the displays.

· ACL acquired the know-how that a controller-actuator can be integrated into an integrated circuit. It knows how and when to decide to start such an integration. It will work with subcontractors, experienced in the design of integrated circuits.

It has acquired a market focus allowing it to benefit from the opportunities to enter new market niches, made possible by the integration of the Electro-luminescent foils in the membrane-switch front-panels.

· The company has learned that a generic controller-actuator was not a product that could be used by all its OEM customers. The controller-actuator needs to be optimised for cost reasons for each specific application, and the company has understood that many OEM customers would rather include the electronics for the controller-actuator in their own electronics, than include it as a physical module, purchased from third-parties.

ACL has managed to transfer the know-how required, as planned, and is know able to transfer this knowledge to its customers. It has hired an electronic technician to support this knowledge transfer. Also on the point of management, and product marketing, the company has strengthened, beyond what was planned. The company has made a transition of being mainly technology driven, to a company that is market driven.

14 Lessons learned.

It is very important to work together with the technical expertise and assistance of third parties. Relying upon external expertise can save of a lot of time and cost, and can significantly shorten the development time for new products.

During the first years of its existence, the small companies often have a technology focus, rather than a market focus. It is very important to listen, and acquire market information from others. Market research provides you with the necessary information on what the market needs. Know-how in marketing can reach the company through the co-operation with specialised subcontractors.

Electro-luminescent foils can be used in a wide variety of applications, requesting each their proper specification with regard to frequency, voltage and power. These 3 last factors influencing colour, intensity and lifetime of the foils.

The company has learned that the core of the electronic circuit can be integrated into a custom ASIC. This will allow a 25% reduction in cost, starting from an annual take-up of 10000 units, and a 50% reduction of cost, starting from an annual uptake of 100 kpcs.

Hiring an electronic technician can be key to success for non-micro-electronics companies, to convince customers, and to help the company to increase market share and to gain access to unexpected market niches.

15 Resulting product, its industrialisation and internal replication.

The resulting product is a controller-actuator developed by ACL witch is multifunctional. It can be used in every market segment. It uses a common core, covering all possible applications that can be implemented in an ASIC.

The resulting product has in fact several levels of implementation:

1. There is a design manual, outlining how an controller-actuator should be designed, and how the frequency, output voltage range and power range can be adapted to the requirements of a specific front-panel or keyboard. The design manual can be sold to the customer, who prefers to integrate the controller-actuator into his own electronics. Remind that most existing customers are original equipment manufacturers, who often prefer not to integrate an additional dedicated electronic module into their equipment. ACL has hired an electronic technician to support its customers in the use of the design handbook.

2. There have been implemented 2 pre-production prototypes, showing the correctness of the design manual discussed above. These existing controller-actuator modules can be sold to the OEM, together with the front-panels and keyboards. ACL does have the know-how to redesign the controller-actuator up to the specific needs of each application for the different customers and has hired a technician to handle re-design and re-optimisation. ACL is not planning to manufacture them in house, but will subcontract manufacturing and test.

3. For large series, ACL will integrate the controller-actuator as an ASIC into the end product. Integration will be subcontracted to a design house, and prototype and volume manufacturing will be subcontracted to Europractice. A feasibility study has shown that saving up to 25% can be achieved for annual volumes of 10.000 units, and up to 50% for volumes of 100.000 units.

The internal replication will consist of developing controller-actuators specially tuned to specific customer needs. ACL will co-ordinate design, production and test, and will deliver them to its customers. Time-to-market for each of these optimised controllers will be 10 to 12 weeks. Development cost will vary between 1 and 5 k€, depending upon the type of invertor, and of the size the Electro-luminescent display.

For the first large OEM customers, ACL will start the development of an ASIC. This ASIC will be done by ACL, in order for it to own the property rights. Time-to-market for the ASIC will be 9-12 months. NRE cost for design, manufacturing and test of an initial ASIC prototype is estimated at 52 kECU, with an additional 25 kECU to ramp-up to high volume production.

Once the ASIC has been developed, ACL will be able to use it for all its customers, also for the customers that only need small volume, since no additional NRE cost will be needed.

16. Economic impact and improvement of the competitive position.

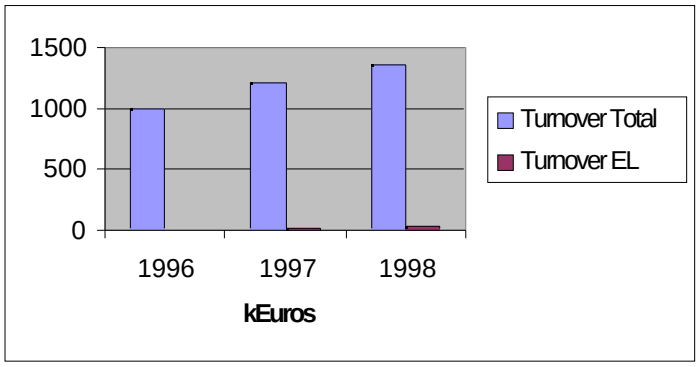
The competitive position of ACL Claeys has been improved by this project. The main Belgian competitors, Velleman and Metagra do not have the electro-luminescent foil technology to include backlighting in the front-panels and keyboards. Their exclusive focus on front-panels and keyboards makes it very difficult for them to make the necessary investment.

Due to investment done by ACL Claeys, they have the possibility to enter new markets, and take a bigger share in the total market of electro-luminescent applications.

In the following section, the turnover of previous sales and future sales are shown, only in the market niche of keyboards and front-panels.

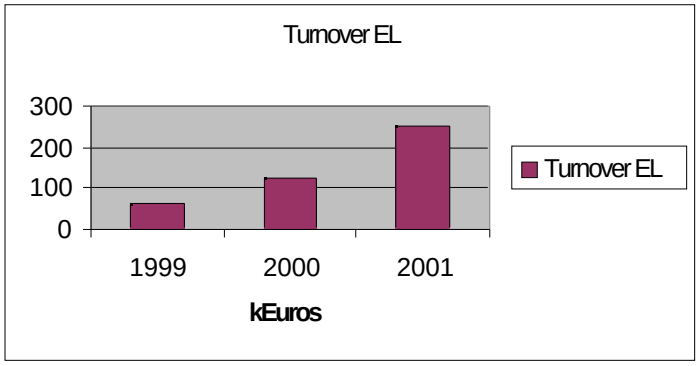
Previous sales in kECU:

	1996	1997	1998
Turnover Total	1000k	1200k	1350k
Turnover EL	2.5k	12.5k	25k
EL as % Turnover	0	1	1,85



Future sales:

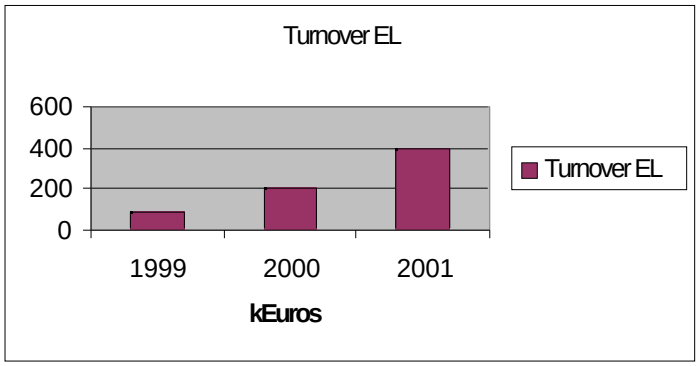
	1999	2000	2001
Turnover EL	62.5k	125k	250k
EL as % turnover	3,6	4,2	5,6



Taking into account the profit margin on the additional revenue, the payback period will be 24 months.

However, new market niches can be entered, taking opportunities of the application of Electro-luminescent foils, not in it's core business of keyboards and front-panels, but in the domain of advertising and road signs. As it will be shown in the following business plans, these new markets will only start generating important revenue in the year 2000.

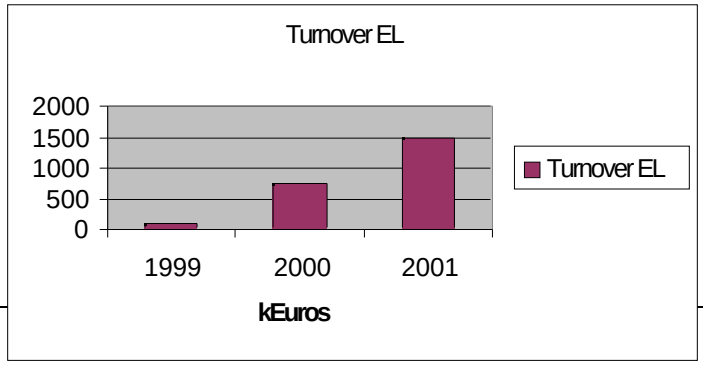
	1999	2000	2001
Turnover EL	85k	200k	400k
%	4,9	6,7	8,9



A wide marketing effort will be needed, because of the large number of possible customers. Taking care of the additional marketing effort required, the payback period will be reduced to 20 months. To allow for the rapid increase, a manufacturing unit has been established in Eastern Europe, providing additional manufacturing capability, at a more competitive cost.

Another market niche that ACL TechnoSwitch is targeting, is the dashboard and control displays in automotive: cars, boats and trains. Here, a marketing effort focusing upon depth, will be required. The approach is to handle the automotive market through a partnership with a supplier manufacturer of conductive layer foils. The volume of the units sold in the automotive market will make it possible to integrate the control in a custom ASIC. The payback period, including the revenue of the automotive applications, will be reduced to 16 months.

	1999	2000	2001
Turnover EL	85k	750k	1500k
%	4,9	16,7	18,8



The AE is expected to have a direct return-on-investment generated by the design-guidelines and the sales of discrete actuators of 12.5 k€ in 1999, and 18.8 k€, 25 k€, 31.2 k€ and 37.5 k€ in the years there-after, leading to a return-on-investment of 239% over a 5-year period.

17. Target audience for dissemination throughout Europe.

Doing this development, the company, basically a non-micro-electronics company, switched from a technology focus, to a market focus. It learned that adding electronics to its product would allow it to enter new market segments, and would increase its penetration within the market segment were it was operating since over 15 years.

The company hired an electronic technician, to be able to profit the most of the know-how gained, and to disseminate and support this know-how to its customer base.

This AE should be disseminated to companies that sell into the OEM market and that have non-electronics products, but where electronics is anyhow an essential part. The idea of selling a 'design handbook' for the OEM who wish to include the electronics on their own board is a good idea.