	Deliverable No 8.7	Final Activity Report – Section 2	
Proposal Number	512931	Proposal Acronym	NAGINELS



Horizontal Research Activities involving SMEs Co-operative Research

Proposal/Contract No: 512931
 Project acronym: NAGINELS
 Project full title: Non AGgressive Internal Engraving Laser System

Start date of project: 1st October 2004 **Duration:** 25 months

Contract for:


CO-OPERATIVE RESEARCH PROJECT
Integrating and strengthening the ERA

DELIVERABLE 8.7: FINAL ACTIVITY REPORT **SECTION 2 – WORKPACKAGE PROGRESS**

Due date of deliverable 1st November 2006
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Organisation name of lead contractor for this deliverable: KS Techniques

Deliverable 8.7	Date	Version
Preparation	1/11/2006	1.0
Final	15/01/2007	1.1


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I DELIVERABLES AND MILESTONES

I.1 Deliverables

Deliverable No	Deliverable title	Initial Delivery date	Nature ¹	Delivery date	Comments
D1.1	The engraving characteristics	T0+6	R	T0+7	Done & sent
D1.2	The engraving rates	T0+6	R	T0+7	Done & sent
D1.3	The industrial constraints to be met by proper engraving processes	T0+6	R	T0+7	Done & sent
D1.4	The main benefits	T0+6	R	T0+7	Done & sent
D2.1	A design study report showing the key design parameters which have been used to meet the expected performances	T0+10	R	T0+12	Done & sent
D2.2	A prototype laser ready for intensive laboratory and field tests	T0+10	P	T0+13	Ready
D3.1	A design study report showing the key design parameters which have been used to meet the performances (technical and costs)	T0+11	R	T0+14	Done & sent
D3.2	A prototype control unit validated using a YAG laser	T0+11	P	T0+11	Ready
D3.3	A vision system validated on samples made by Femto laser in WP1	T0+11	P	T0+9	Ready
D4.1	A mock-up, engraving unit with its control unit at laboratory scale	T0+12	P	T0+14	Ready
D4.2	A report describing the preliminary engraving characteristics obtained with the controlled Femto laser-based engraving process	T0+12	R	T0+15	Done & sent
D4.3	Specifications of the field tests to be performed with the real objects	T0+13	R	T0+15	Done & sent


¹ Nature of the deliverable using one of the following codes:

R = Report


P = Prototype

D = Demonstrator

O = Other

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D5.1	A design study report showing the key design parameters which have been used to meet the expected process performances (including cost of ownership)	T0+18	R	T0+25	Done & sent
D5.2	a prototype engraving process ready for intensive field testing at production rates typical of an industrial unit	T0+18	P	T0+21	Ready
D6.1	A report describing the field test results (qualitative and quantitative)	T0+23	R	T0+25	Done & sent
D6.2	A report that contribute to the final Plan for Using and disseminating the Knowledge	T0+23	R	T0+25	Done & sent
D7.1	A web site is available for result dissemination	T0+4	O	T0+7	Done www.naginels.com
D7.2	Two papers have been presented in professional conferences before the contract end	T0+24	R		The consortium decided not to allow scientific papers seeing the patent & confidentiality needs
D7.3	A concluding seminar has been held as the final contract meeting with representatives of the European glass makers	T0+24	O	T0+25	Glasstec exhibition in Dusseldorf
D7.4	A report on recommendations for the use of Femto laser engravings in the antifraud and normative marking field	T0+24	R	T0+25	Done & sent
D8.1	Mid term activity report	T0+12	R	T0+12	Done & sent
D8.2	Mid term Management report	T0+12	R	T0+12	Done & sent
D8.3	2nd activity report		R	T0+25	Done & sent
D8.4	2nd Management report		R	T0+25	Done & sent
D8.5	Intermediate Plan for Using and Disseminating Knowledge	T0+12	R	T0+12	Done & sent
D8.6	2nd Plan for Using and Disseminating Knowledge		R	T0+25	Done & sent

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D8.7	Final activity report	T0+24	R	T0+25	Done & sent
D8.8	Final Management report	T0+24	R	T0+25	Done & sent
D8.9	Final Plan for Using and Disseminating Knowledge	T0+24	R	T0+25	Done & sent

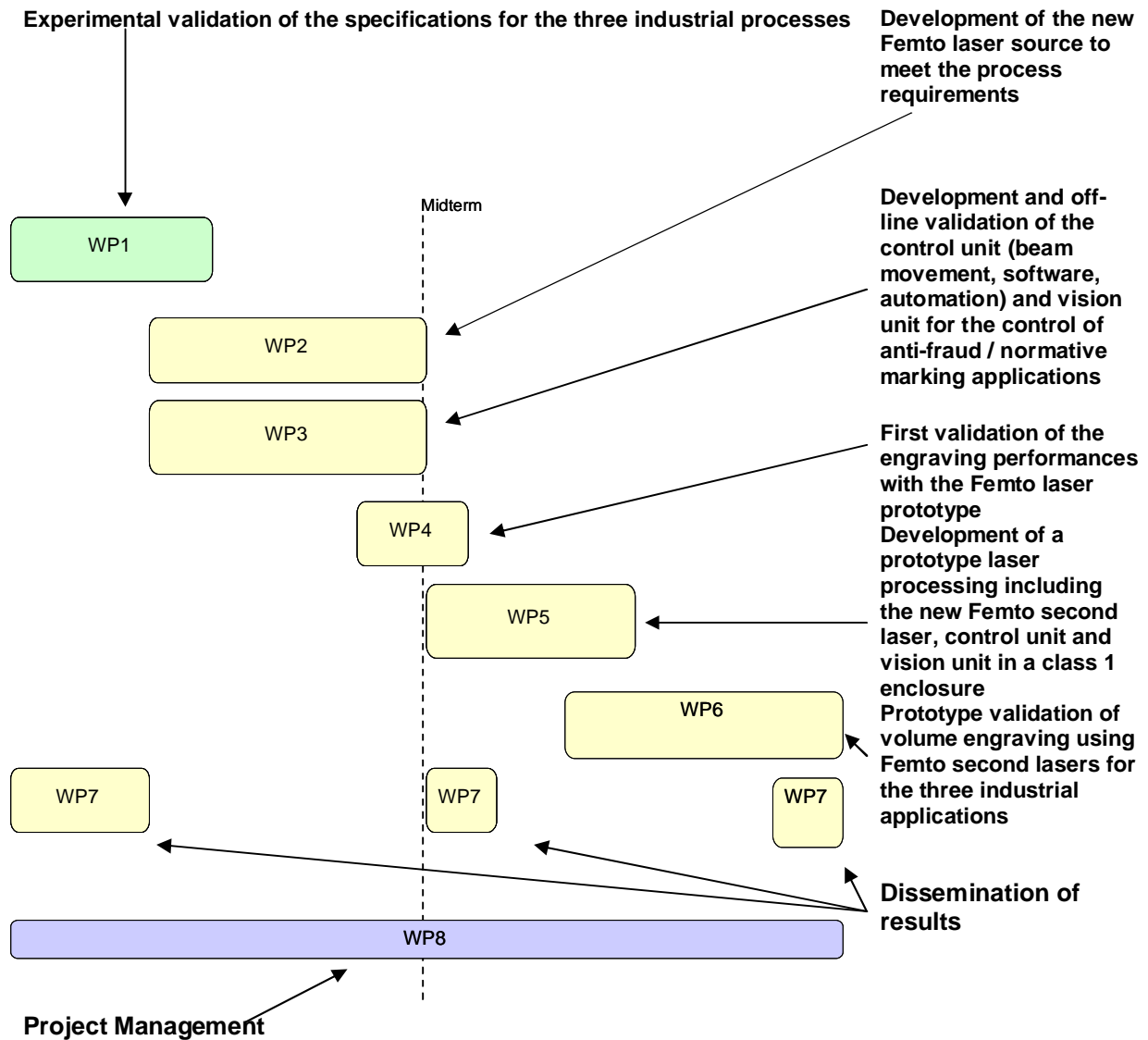
1.2 Milestones


	Linked to WP n°	Initial date	Date	Description	Comments
M1	1	T0+ 6	T0+ 7	The process specifications for the three applications are approved by the consortium	<i>Better results than expected - one test month complementary</i>
M2	2	T0+10	T0+13	The prototype Femto laser source using Ytterbium crystals is available for tests	<i>More ambitious performances has been defined – two months late for the final mechanical structure Three month late</i>
M3	3	T0+11	T0+12	The control unit of the engraving process is ready for laboratory experiments	<i>One month late (seeing WP2 delay)</i>
M4	4	T0+12	T0+15	The Femto laser engraving process performances meet the specified requirements with regards to qualitative et quantitative targets	<i>delayed of three months (seeing WP2 & 3 delays)</i>
M5	5	T0+18	T0+21	The industrial prototype is ready for intensive testing	<i>First design has been done in advance. The manufacturing phase has begun with 2 month late (seeing WP4 delay)</i>
M6	6	T0+23	T0+25	The system performances at prototype level have been measured for the three applications	<i>Many tests have been done with laboratory setup waiting for the industrial prototype (delayed of 3 months)</i>
M7	7	T0+24	T0+25	A final meeting is held as a dissemination seminar towards all the intermediaries which can use laser engraving of transparent materials in the three applications, inviting also end users	<i>Web Site is available: www.naginels.com Patent has been deposit Glasstec Show (Dusseldorf) See PUDK for more details</i>

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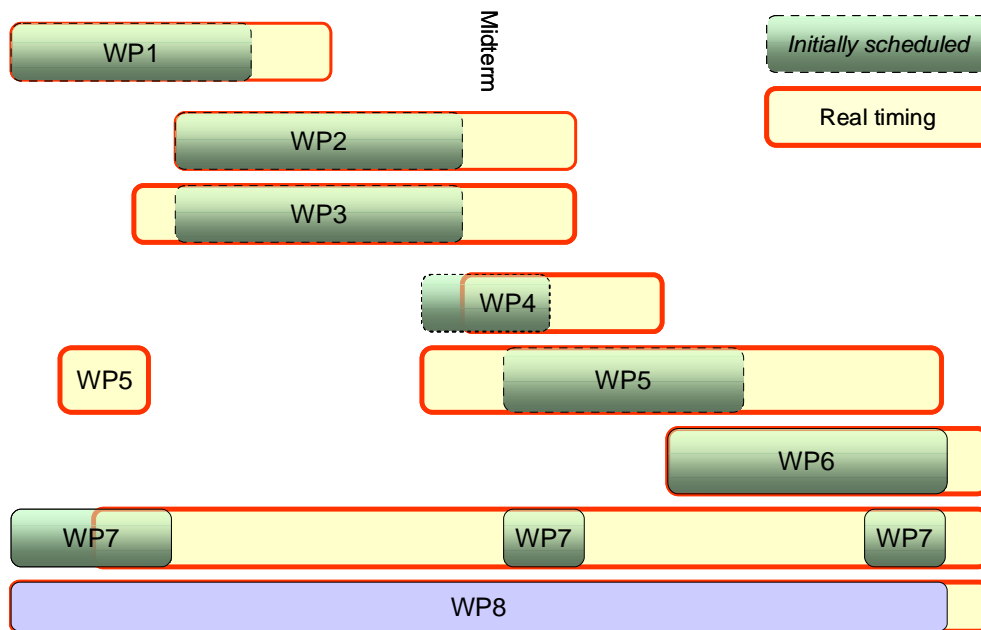
II WORK FLOW

II.1 Initial work flow



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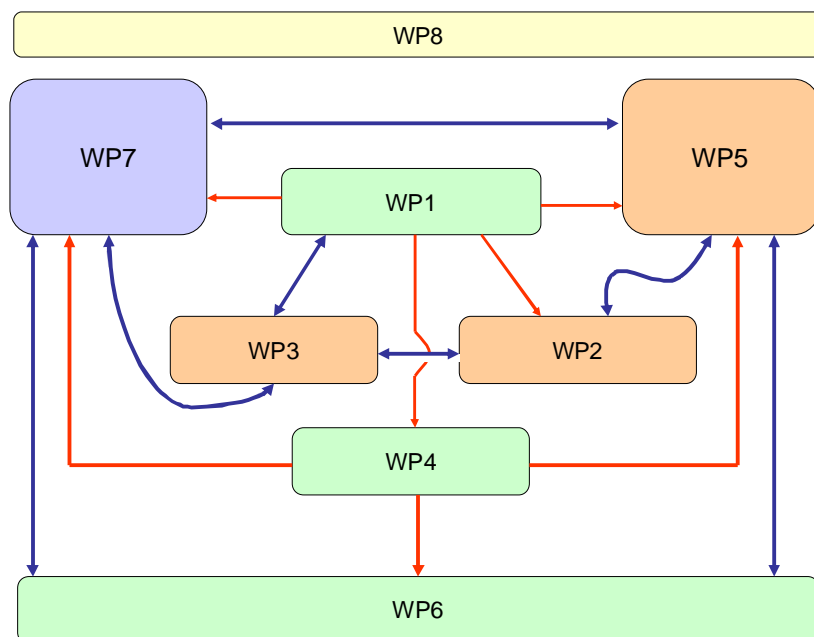
II.2 Real work flow




Comparison between WPs timing initially scheduled and real timing

II.3 Interaction between work packages

*Interaction between workpackages (**bidirectional** or **unidirectional**)*



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III DETAILED ACTIVITY PER WORKPACKAGE


III.1 WP1 Experimental validation of the specifications

III.1.1 Work package flow chart

The Work Package WP1 begun the 1st October 2004. The SMEs and RTDs companies have had to detail the specifications of the new process, the functional description of the needs for the system to be developed, and the possibilities of the new technology. The first elements were shared during the Kick off meeting that took place the October 2004 in Lasea, under the management of KST. These first elements became the basis of the functional description of laser engraving process. SOLOS and TBS worked especially on the specifications for anti-counterfeiting applications, Costet worked especially on the specifications for decorative applications and anticounterfeiting applications dedicated to perfume bottles manufacturing industry. KST worked especially on the specifications for normative applications.

Moreover, Costet and KST begun to work on the specifications of future systems, as well as the integration of the technology in manufacturing plant. These elements became the basis of the design of the Naginels prototype (WP5.1) and defined the environment specifications for the laser sources (WP2.1).

In the same time, CSL and Lasea prepared the first campaign in Bordeaux (Samples preparation, protocols preparation, optics to test,...). The first campaign (one week) was held on the week 48 in the presence of PALA, Amplitude, CSL and Lasea. First analyses were made on site thanks to the material of PALA. The samples went back to Lasea to be analysis by CSL and Lasea thanks to the Lasea and CSL equipments. First results were communicated to the SMEs and some samples were sent to SMEs in order to be analysed. Then new samples were sent by SMEs to Lasea and PALA to be tested during the second camping (one week) in Bordeaux (week 50). More samples were proceeded and e dedicated to the development of reading system (WP3.1). Analyses on the new samples were then realised during the two next months by CSL, Lasea and the SMEs before a new campaign (one week) in Bordeaux on the week 5. More samples for the SMEs and end-users were done in order to prepare the WP1 meeting. New analyses were made and reading tests were realised thanks to the first prototype of reading system developed in the WP3.3.

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The WP1 meeting has taken place at Lasea, under the management of KST, on the 15 February 2005. All the results of the different partners were shared and a demonstration of the first prototype system was shown. The definition of the laser source was decided by the SBB allowing to Amplitude to begin the development and manufacturing of the new fs laser source.

A new campaign dedicated to decorative applications was also decided. This campaign has held on the second week of March 2005 in PALA.

Thanks to the results, the analyses and the documents received by the different partners on the specifications, all the elements were summarised in different deliverables sent to the Commission in the beginning of May:

Deliverable No	Title
1.1	The engraving characteristics
1.2	The engraving rates
1.3	The industrial constraints to be met by proper engraving processes
1.4	The main benefits

The main points of these reports are summarized in the following task descriptions.

III.1.2 WP1.1: Functional description of the laser engraving processes


The RTDs (CSL, PALA, Amplitude and Lasea) have described to SMEs (KST, Costet, TBS and SOLOS) the possibilities of femtosecond engravings. They have presented to other partners requirements and advantages of femtosecond laser machining, especially for marking applications. Laser marking could be achieved on the surface or under the surface.

Then they have assisted the fourth SMEs regarding the different options available in terms of laser technology. We have concentrated on the following elements:

- » Up-time and reliability of the process
- » Engraving productivity for various materials of interest for the three areas of applications

They have reviewed the different laser options offering maximum productivity. During the definition of the process, one should concentrate on

- (i) evaluating the technical feasibility, which depends mainly on the laser pulse energy and
- (ii) evaluating the productivity, which mainly depends on the laser pulse repetition rate.

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Two main types of laser are envisioned for NAGINELS: An oscillator, delivering low energy per pulse (in the nanoJoules range), but with a very high speed, and an amplifier, delivering higher energy per pulse (in the microJoules range), with lower repetition rates (in the range 10-100 kHz).

The three applications (decoration, anti-fraud marking and normative marking) are described using a functional approach:

- TBS and SOLOS describe the needs for antifraud applications.
- COSTET describes decorations with possible anti-fraud signatures.
- KST describes normative marking.

Costet and KST also discussed about the specifications of on-line and off-line future systems and prepared the design of the future prototype (WP 5.1).

The results of the functional description are summarized in the deliverable 1.3, based on the different reports of the SMEs. It is divided in 5 main parts. The three first parts detail the needs for the technology and the markets. The two last ones detail the specifications for the integration of this technology in systems or production lines:

- » Chapter II: Description of the needs for decorative applications p 6
- » Chapter III: Description of the needs for anticounterfeiting applications p 11
- » Chapter IV: Description of the needs for normative applications p 42
- » Chapter V: Specifications on integration p 49
- » Chapter VI: Functional description of future systems for decorative applications p 55

III.1.3 WP1.2 to 1.4 Experimental tests and results interpretation

The experimental tests have been divided in four tests campaigns and analyses dedicated to the three applications.


III.1.3.1 Lasers used

- » *The fs oscillator*

The oscillator is the **t-pulse** 100 enabling to have 200nJ @10MHz

- » *The fs amplifier*

The amplifier is the **s-pulse** enabling to have 70μJ @10kHz

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III.1.3.2 Samples treated

The tests were carried out on several types of samples:

- 1) On standard glass (float) 80 x 80mm - 80 x 50mm - 50 x 50mm thick. 5mm, prepared by CSL

Most of the orientation and analysis tests were carried out on these 3 types of samples.

- 2) Laminated glass
- 3) Toughened glass
- 4) Perfume bottles
- 5) Vials (pharmacology)
- 6) Syringe
- 7) Wine bottles

III.1.3.3 The experiments

The experiments were carried out during 4 test campaigns done at the PALA in the presence of Amplitude, CSL and Lasea. For each optical configuration tested, the tests were carried out in 4 fields for which we made the intensity, the speed and the filling vary:

- 1) Squares of different sizes



- 2) data matrixes of different sizes



- 3) series of points with a variable number of pulses



- 4) diffractive networks




- 5) lines of different speeds



All samples are identified with:

- a A reference (Name of sample)
- a A number (No of sample)
- a An identifying for each engraving (ID)

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All the parameters (laser type, optical configuration, speed, repetition rate, distance between lines – points, type of engraving,...) are linked by the post-analyses (length, reading, ageing tests, diameter measurement, ...) and with the photos. The table summarising these data's is annexed to the present document.

III.1.3.4 Summary

- ü 2 fs-lasers tested
- ü 12 optical configurations tested
- ü 110 samples realised
- ü 620 tests with different parameters realised

Analyses :

- ü 310 photos with microscopes
- ü Length analyses
- ü Diameter analyses
- ü Spectrum analysis
- ü Reading analysis for datamatrix (Thanks to reading device (WP3.4))
- ü Heating tests on samples
- ü Absorption tests with laser

III.1.3.5 Details of the four campaigns


» First campaign

The first campaign focused on the test with the amplifier and a one combination of focal length and beam expander – *configuration 4*.

- a 20 samples realised
- a 102 tests with different parameters realised

Finally we have treated the first samples received from the SMEs and end-users:

- *For the automotive field*
- *For the pharmaceutical field*
- *For the perfume field*
- a 16 samples realised
- a 86 tests with different parameters realised

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We have treated flat glasses of 80 x 50mm enabling us to draw up our theoretical conclusions..

Finally we have treated the first samples received from the SMEs and end-users:

- a *For the car sector.*
- a *For the pharmaceutical sector.*
- a *For the manufacture of small bottles sector.*

» **Second campaign**

The second campaign first focused on the oscillator then on the amplifier with 3 different focal lengths

Test on the oscillator

- r 6 samples realised
- r 12 tests with different parameters realised

Three configurations using three combinations of focal length and beam expander were tested. None of the configurations enabled to observe any effect at this low energy. It was then decided to proceed again on a amplified configuration.

Test on the amplifier

Three configurations using three combinations of focal length and beam expander were tested.


We have treated flat glasses of 80 x 50mm and flat glasses of 80 x 80mm enabling us to draw up our theoretical conclusions.

- ü 15 samples realised
- ü 40 tests with different parameters realised

Finally we have treated the first samples received from the SMEs and end-users :

- *For the automotive field*
- *For the pharmaceutical field*
- *For the perfume field*

- ü 12 samples realised
- ü 20 tests with different parameters realised

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Several small bottles received from TBS and Costet have also been treated with another combination of focal length and beam expander *configuration 7 & 8*

- *Conf 7:*

- 2 x 3 bottles
- 2 x 3 vials

- *Conf 8:*

- 3 bottles
- 3 vials

» **Third campaign**

Three configurations using three combinations of focal length and beam expander were tested.

We have treated flat glasses of 50 x 50mm enabling us to draw up our theoretical conclusions.

- ü 20 samples realised
- ü 280 tests with different parameters realised

Finally we have treated the first samples received from the SMEs and end-users:


- *For the automotive field*
- *For the pharmaceutical field*
- *For the perfume field*

- ü 25 samples realised
- ü 80 tests with different parameters realised

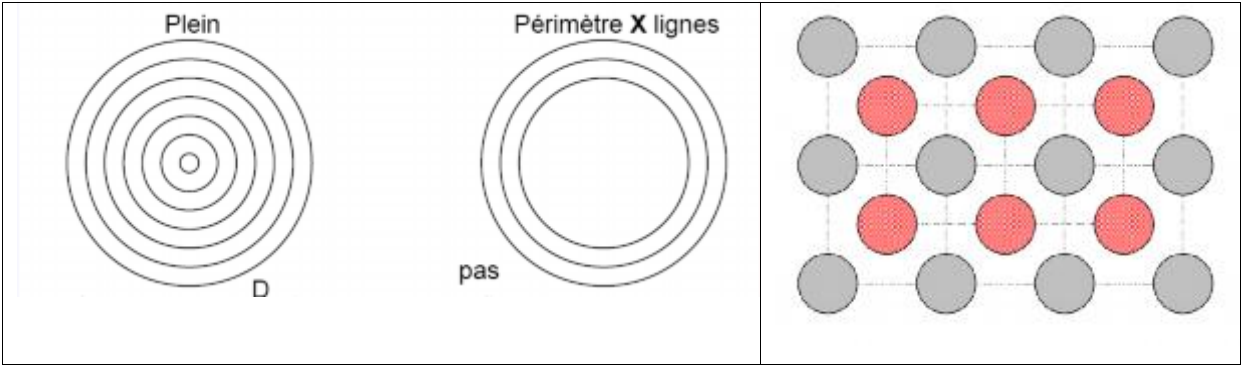
» **Fourth campaign**

For this special campaign more dedicated to decorative applications end-user (mainly COSTET), we used a fs amplifier laser in the configuration 4.

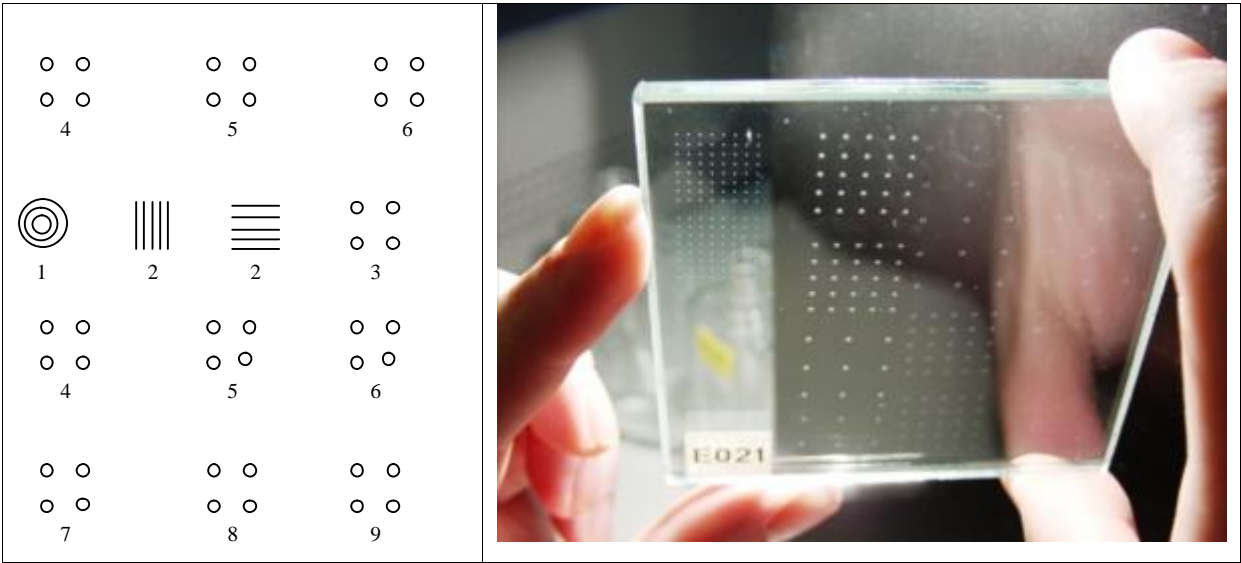
We were looking for glittering or shining effect on flat glass and perfume bottle. Glittering effect was achieved using a new pattern (intra-volume marking), which consists in a square arrangement of sub-pattern (disc or annular shape). Each sub-pattern is a group of concentric circles. The distance between two neighbour circles is equal twice the spot diameter ($2 \times 5\mu\text{m}$). For a disc shape, circle diameter goes from zero to 0.2 or from zero to 0.8


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mm. For a annular shape, circle diameter goes from 0.4 to 0.8 mm (20 circles) or from 0.6 to 0.8 mm (10 circles).



We made samples with various step (distance between to sub-pattern) from 1.6 mm to 6.4 mm. Spot speed on the target was 20 or 40 mm/s. All trials were performed at 5 kHz with a 10 μJ pulse energy (energy on the target). A good glittering effect was obtained for 40 mm/s spot speed and with 20 circles annular shape. Glittering effect is visible under white (sun) light or under artificial light.



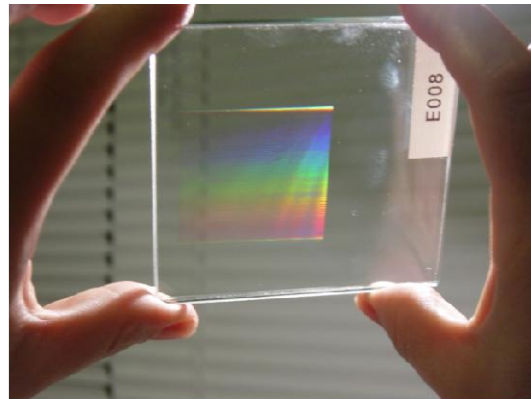
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III.1.3.6 Analyses

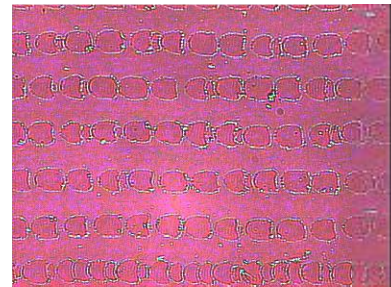
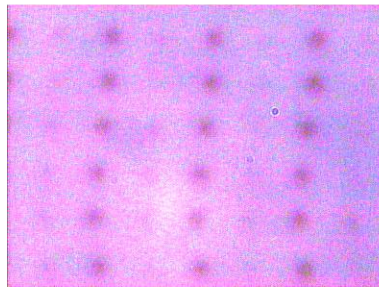
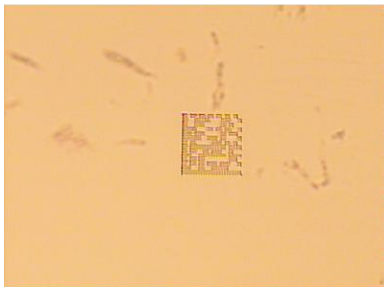
Many analyses have been realised on the samples, allowing having the best conclusions for our process and taking the optimal decision for the future developments:

- a theoretical analyses
- a 310 photos with microscopes

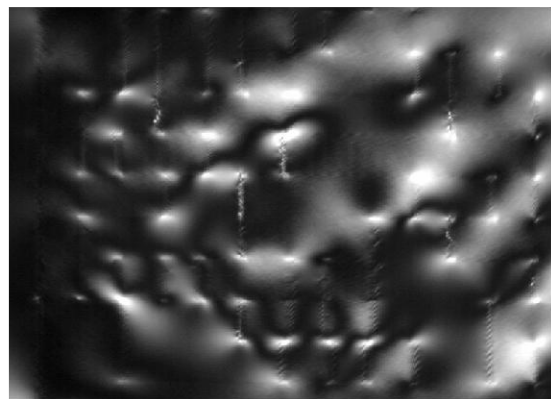
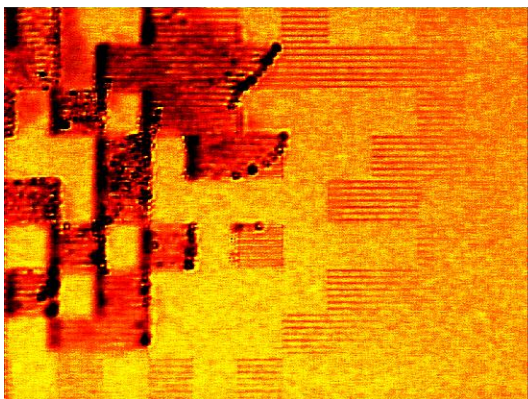
for the diffractive index change :




for the color change :

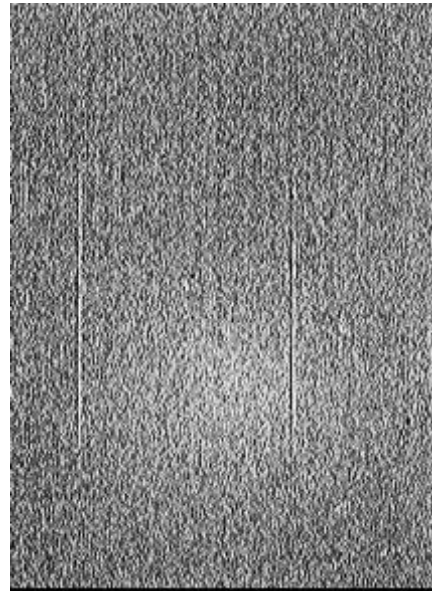
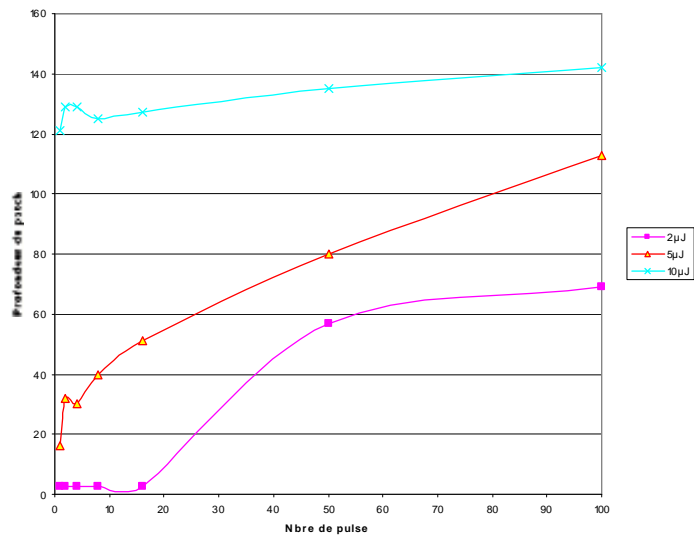


for the structural change :

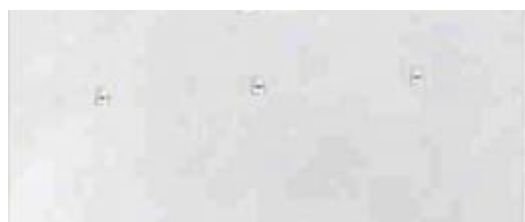
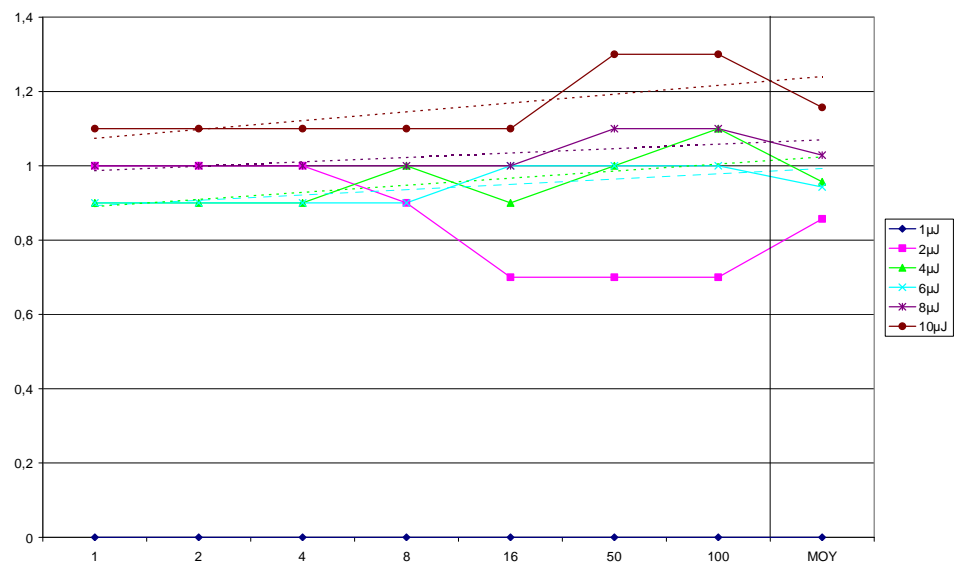



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a Length analyses

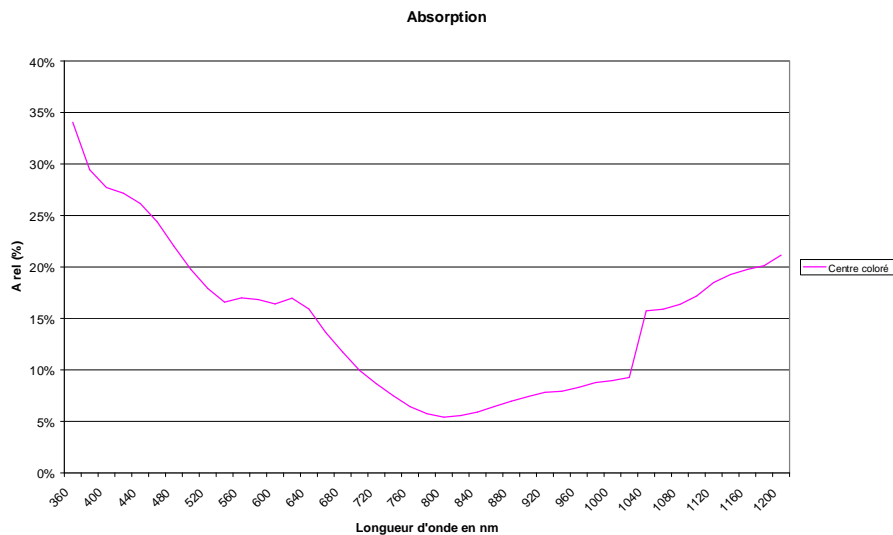


a Diameter analyses

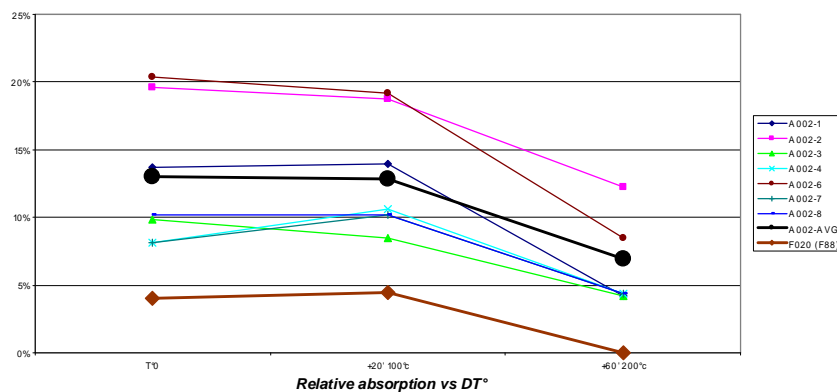


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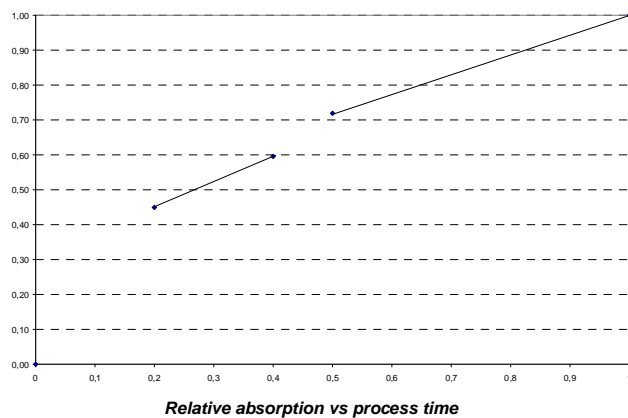
a Spectrum analysis




a Ageing tests on samples



a Absorption tests with laser



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a Reading analysis for datamatrix (See WP3.3)

All these analyses took a lot of time. For example, the measurement of the length of the laser engraving needs by sample:

A Post-marking preparation:

- » Sampling of the exposed area 38 x 10 mm (wire saw)
- » Polishing of the external edge
- » New label 'Sample reference (ie E011) top' on the entrance end of the laser beam
- » Visualization of the markings in the axis

Material : Nikon Eclipse diascopy in polarization obj. X5
Nicom VHR2000 Camera

Image data stored in the files

Analyses

In the series at 5 and 10 μJ all the points are perceptible, on the other hand at 2 μJ only 50 and 100 impulses give a definite result (16 begins to appear)

We also have perceptible though limited results (only in near-crossed position) of birefringence. In the DM, these effects are long-distance in relation to the marking point (cover in a continuous way the matrix thread / pace).

Visualization of the markings in lateral

Material : Nikon Eclipse diascopy in polarization Obj. X20
Nicom VHR2000 Camera
Image processing by gradient filter IMAQ 7X7 n° 5

Analyses

Only the gradient filtering enables to make an easy observation.


The images mostly take up 2 marks the bottom one is referenced 'boot' and the top one 'top' in the file name. The image data are stored in the files

Analyses

The 2 μJ series gives lengths limited to 70 μm half of which on an ante focalization and the other of reversed contrast on a post focalization. This phenomenon is not observed at the other energies

The 5 μJ series does not show any post focalization mark but a retro progression (extension of the dimension towards the laser) of the mark for an increasing number of impulses. It starts at a length of about 20 μm for one impulse. The progression in length is rather random to end up in a bit more than a hundred of μm at 100 impulses. The mark always remains linear, of a maximum diameter of a few μm (2 to 3) with sometimes interruptions (in particular for 50 and 100 impulses)

The 10 μJ series directly starts with a length of 120 μm for one impulse then extends at saturation at about 140 μm . Except for 50 and 100 impulses no parasitic appears around the mark which remains quite linear.

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Besides, the reference spot presents a conical filamentary structure

Reading of the mark lengths

The error of measure in the figures below strongly varies from one case to the other (because the image contrast is weak). It is typically $\pm 2.5 \mu\text{m}$ and can partly explain the non uniformity of the growth of the mark lengths with the number of impulse in the case $5 \mu\text{J}$. The lengths are in μm :

E (μJ)/nbr pulse	1	2	4	8	16	50	100
2						57	69
5	16	32	30	40	51	80	113
10	121	129	129	125	127	135	142

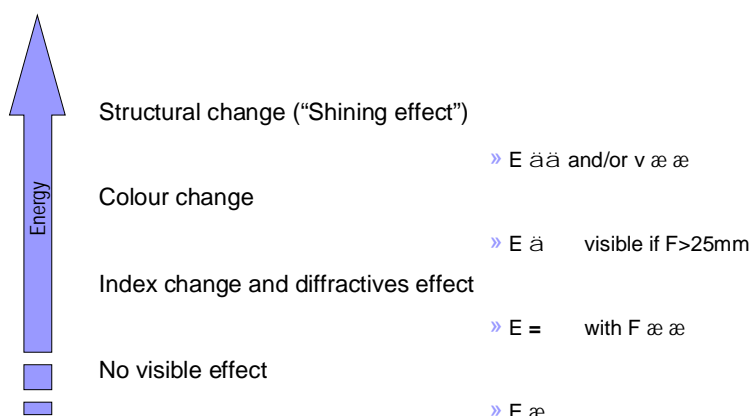
III.1.4 WP1.5 Summary of the main benefits


The results, interpretation, and parameters are studied in details and summarised in reports in order to influence the design of the new Femto laser and the control unit.











A meeting with all the partners was held in Lasea, under the management of KST on 15th February 2005. The first results were shown and decisions necessary for the following tasks of WP2, WP3 and WP7 have been taken.

Results for the process:

Results : the three effects depending of level of energy














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-  No results with oscillator and $E < 150\text{nJ}$
-  Disappearing of the colour change with F88 $E < 17\mu\text{J}$ on glass bottles
- 
-  Datamatrix with diffractive effect very readable (75% A_{AIM}) with low energy
-  Datamatrix with colour change readable (11% F_{AIM})
-  Irisation effect for decorative applications feasible with low energy
-  No disappearing of diffractive effects even with 1h 200°C
-  Datamatrix of 0,06 x 0,06mm feasible and readable with short focal length
-  Datamatrix of 0,2 x 0,2mm feasible and readable with F 88
-  Waveguides on glass

Results for the development of laser source (WP2):

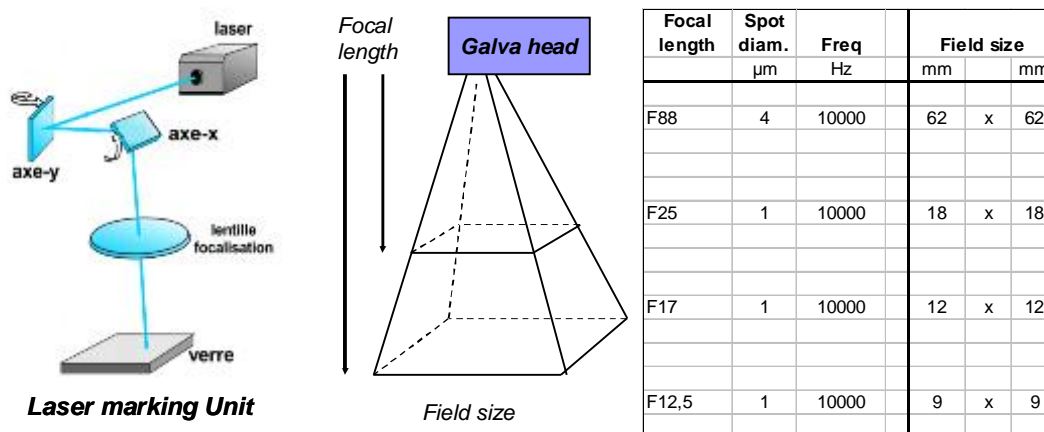
1. Choice of the laser type

<i>Oscillator</i>		<i>Amplifier</i>	
<u>Actual dvpt</u>	0,2 μJ @11MHz		70 μJ @10kHz
<u>possible dvpt</u>	1 μJ @ 1MHz		10 μJ @ 100kHz
<u>Characteristics</u>			
	Cheaper		High energy E_{max} up to 100 μJ
	Smaller		More expensive
	High repetition 11MHz		
	Low energy E_{max} 0,2 μJ		
<u>Process</u>			
	No results with $E < 150\text{nJ}$		Permanent colour change $E > 30\mu\text{J}$
	No results* with $E < 1\mu\text{J}$		Permanent diffractive effect $E > 4\mu\text{J}$

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Results for the development of laser control (WP3):

2. Choice of the configuration and frequency



2. Choice of the configuration and frequency

Amplifier

70 μJ @10kHz

Focal > 80mm

“Low” Resolution (>5 μm)

“High” Field size (>60x60)

Amplifier

10 μJ @100kHz

Focal < 25mm


High Resolution (1 μm)

Limited Field size (<20x20)

Process

- 😊 Permanent colour change
- 😊 Structural defaults (but μdamage ?)
- 😞 Low process time
- 😞 No diffractive effects
- 😞 Poor contrast (11%)

- 😊 Diffractive effect
- 😊 Invisible but readable Datamatrix
- 😊 High speed process
- 😊 High contrast (75% AIM)
- ? Waveguides on glass
- ? Permanent colour change (very thin)
- 😞 No structural defaults

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Conclusions for the following research and objectives

1. Normative applications

Initial objective :

	Qualitative	Quantitative
Normative marking	High contrast with high information number (datamatrix and bar codes) for 100 % control	An easily readable code is engraved in less than 0.50 seconds with sufficient data (10 ¹⁶ references or 10 alphanumeric data's)

Data's :

Rows x Columns 14 X 14	Numeric Only (0-9) 16	Alphanumeric (0-9, A-Z, space) or (0-9, a-z, space) 10	8-bit ASCII (0-255) 6
-------------------------------------	---------------------------------	--	---------------------------------

Process time for datamatrix 1 x 1mm :


70µJ@10kHz

10µJ@100kHz

Focal length	Spot diam.	Freq		Field size		actuel	futur	
	µm	Hz		mm		tmax	tmax	Contrast
F88	4	10.000	10.000	62	x 62	10,0	10,0	11%
F25	1	10.000	100.000	18	x 18	10,0	1,0	75%
F17	1	10.000	100.000	12	x 12	5,0	0,5	75%
F12,5	1	10.000	100.000	9	x 9	5,0	0,5	75%

Conclusion :

Objective OK if 10µJ@100kHz

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2. Anti-counterfeiting applications

Initial objective :

	Qualitative	Quantitative
Antifraud	Minimal size of the signature (100 micron datamatrix or special codes)	A code is engraved in less than 0,10 seconds with sufficient data (10 ¹⁰ references or 6 alphanumeric data's)

Data's :

Rows x Columns	Numeric Only (0-9)	Alphanumeric (0-9, A-Z, space) or (0-9, a-z, space)	8-bit ASCII (0-255)
14 X 14	16	10	6

Process time :

pe :

	Focal length	Spot diam.	Freq	Field size			DM			actuel	futur	
		µm	Hz				min			tmax	tmax	
70µJ@10kHz	F88	4	10.000	10.000	62	x	62	0,22	x	0,22	0,50	0,502
	F25	1	10.000	100.000	18	x	18	0,06	x	0,06	0,03	0,003
10µJ@100kHz	F17	1	10.000	100.000	12	x	12	0,06	x	0,06	0,02	0,002
	F12,5	1	10.000	100.000	9	x	9	0,06	x	0,06	0,02	0,002

Conclusion :

Objective OK if 10µJ@100kHz

Initial objective :

	Qualitative	Quantitative
Decoration	New colours or new type of designs based on refractive index change	10 ⁵ "pixels" engraved in less than 5 seconds for a cost of 0.5 Euros

New type of design :

Irisation effect Structural change (-)
Waveguides (?) Colour change (-)


Process time :

ne :

Focal length	Spot diam.	Freq		Field size					Taille 2D (3D?)		
	µm	Hz		mm		mm	points in 5s		mm²	mm²	
70µJ@10kHz	F88	4	10.000	10.000	62	x	62	50.000	50.000	1,25	1,25
	F25	1	10.000	100.000	18	x	18	50.000	500.000	1,25	12,50
10µJ@100kHz	F17	1	10.000	100.000	12	x	12	50.000	500.000	1,25	12,50
	F12,5	1	10.000	100.000	9	x	9	50.000	500.000	1,25	12,50

Conclusion :

Qualitative objective OK if 10µJ@100kHz but designs very small

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III.1.5 WP1.6 Risk management of the work package

KST has set-up an internal project review committee. This work package was the first, but also the most important because it will define the design of the laser source, the design of the first prototype and give tanks to the experiments a precise idea of the future performances of the system. This work package is the most difficult to manage seeing that all the partners are involved in the different tasks. Performances of the innovative system are well beyond the expected performances. Since the first test campaign, it was decided by the Consortium to go more deeply in the tests and the work package took for this reason more time and manpower than expected. The summary of the RTDs work was made by Lasea and the summary of SMEs work by KST. One month was dedicated to stick together all the reports and make the four deliverables of this Work Package. The results have decided also the Consortium to discuss the opportunity to deposit a patent. This decision was confirmed in Liège during the Work package 3 meeting.

III.1.6 Conclusions

The WP1 meeting was held in Liège on the 14th February 2005.

All the initial objectives are successful. The design of the laser source (WP2) was confirmed, as well as control system and reading design (WP3). Thanks to the functional description of the future equipments, design of the system (WP5) has begun to be studied. Seeing the very good results, it was decided to postpone the web site (WP7.1) and to diffuse little information in order to wait for the protection of a patent (new task of WP7)).

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III.2 WP2 Development of the new Femto laser source


III.2.1 Work package flow chart

The Work package objectives are:

- a Design a prototype system consistent with WP1 outputs
- a Build a prototype for laboratory and field application

The Work Package WP2 begun the 1st February 2005, as expected initially.

- The SMEs and RTDs companies have had to detail the specifications of the new laser source regarding the functional requirements. The first elements were shared during the WP1 meeting that took place the 15th February 2005 in Lasea, under the management of KST. The decisions taken in this SBB allowed Amplitude to go on the design task of the new laser source (WP2.1). Costet and KST worked especially on the specifications for the industrial environment of the laser source, leading Amplitude to design a sealed mechanical structure. Amplitude has conducted thermo-mechanical simulations for the mechanical engineering of the laser, including finite element analysis computer runs, which required more resources initially defined.
- KST and Lasea worked especially on the specifications for communications between the control system and the laser source.
- The final specifications for the laser have been greatly improved compared to the initial NAGINELS target (for instance, the laser speed has been increased by a factor of 10, from 10 kHz to 100 kHz). This required that Amplitude allocate more resources to the design phase than initially foreseen.
- A midterm meeting took place in Bordeaux on 14th June 2005 in Amplitude installation with all the partners to review the key parameters. The prototype in a laboratory scale was shown.
- The integration of the prototype in its mechanical structure was delayed of one month mainly due to difficulties and supplier-related delays on several issues, for example in the realisation of the laser mechanical structure

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All the elements of the new laser source were summarised in the deliverable 2.1 (38p) sent to the Commission in the beginning of October. The document is divided in 6 main parts. The three first parts will detail the needs for the technology and the markets. The second one details the specifications for the laser source, the fourth one the key steps of the design:

» Chapter II:	Laser Specifications	p 5
» Chapter III:	Femtosecond laser technology	p 7
» Chapter IV:	Design Report	p 11
» Chapter V:	Experimental Result	p 37
» Chapter VI:	Summary	p 39

The main points of these reports are summarized in the following task descriptions.

III.2.2 WP2.1 Design of the new Femto laser source

III.2.2.1 Specifications

Two lasers were tested in WP1, the conclusions were:

- High energy laser oscillator


- No visible effect
- Colour changes disappear after a few weeks
- Contrast of colour changes decreases with thermal stress

- 10 kHz laser amplifier

- Structural, refractive index and colour changes possible with 1-10 mJ energy
- Processing speed needs to be improved, especially for decorative applications

Following the results of WP1 and the first design study of Amplitude, the Consortium has decided in the development to place a special emphasis on processing speed, and has decided during the progress meeting on February 15, 2002, to aim for the following specifications:

	<i>Target specification</i>	<i>Comment</i>
Pulse Energy	10 μ J	Compatible with all applications
Repetition rate	100 kHz	Reduce process time
Pulse duration	500 fs	Non aggressive process
Beam quality	TEM ₀₀	High resolution, small spot size

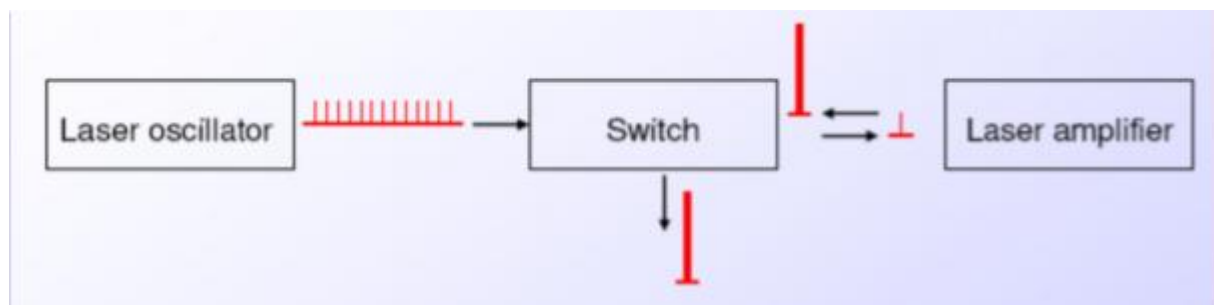
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III.2.2.2 Design


Amplitude has performed a detailed design of this new laser source, with main emphasis on:

- a Optical engineering, to reach the desired specifications.
 - a Development of a high repetition rate amplifier
 - a Optimisation of laser efficiency
 - a Simplification of the laser source
- a Electrical engineering, to be able to operate at repetition rates well above the initial target for the project.
 - a Thermomechanical analysis
 - a Sealed, rugged laser source
- a Mechanical engineering, to guarantee the reliability of the system.
 - a High speed optical switch
 - a Interfaces

III.2.2.3 Principle of operation



- a A laser oscillator delivers a train of low energy, short pulses
- a An optical switch extracts a single pulse from the train.
- a The pulse energy increases in a laser amplifier.
- a The optical switch extracts the high energy pulse.

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III.2.2.4 Goal

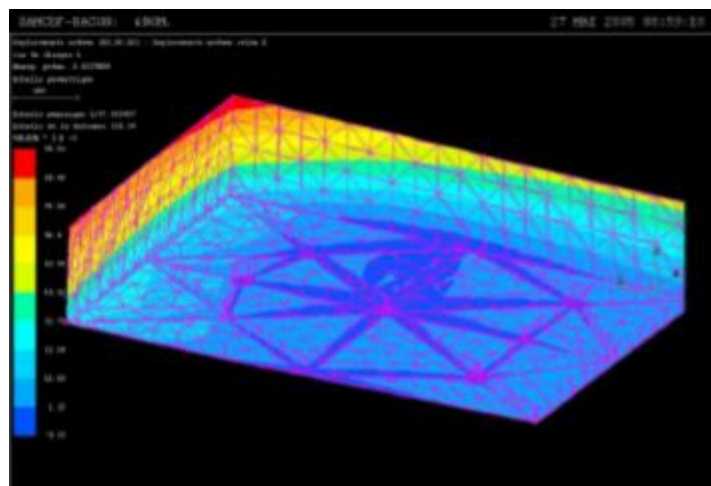
- a Stable, rugged, lightweight laser housing
- a Stability vs. temperature change
- a Sealed for operation in a factory environment.

III.2.2.5 Structural analysis

- a Finite elements analysis
- a Moulded structure vs. baseplate


Five configurations analysed

- § Two different monolithic structures
- § Three baseplates with different thickness



Outputs:

- o Temperature field
- o Displacement dx,dy,dz
- o Angular distorsion

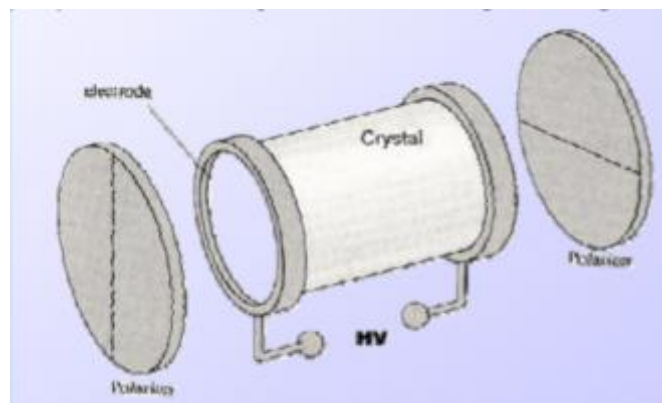
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III.2.2.6 High speed electro-optical switch

- a Switch a low energy femtosecond pulse in and out of the amplifier.
- a Fast switching time to separate two adjacent pulses.

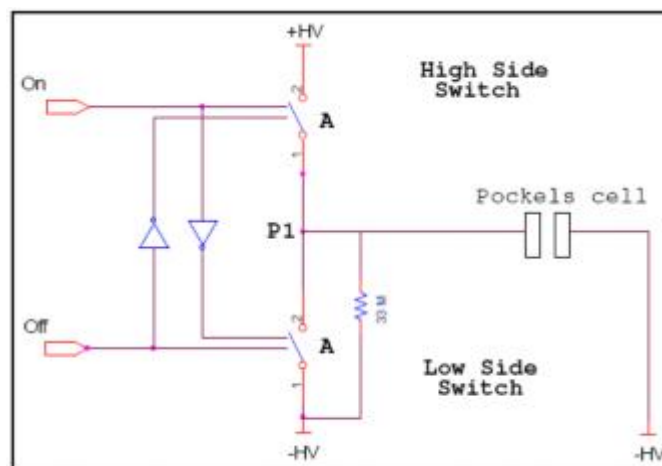
Pockels cell effect:


- Change of the optical properties of a crystal when a high voltage is applied.



Electrical engineering

- High repetition rate, high voltage, 5 ns risetime.



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III.2.2.7 Communication between the laser source and control system


The communications were discussed and optimized with Amplitude, Lasea and KST.

- a Constitutive elements :
 - a 2 racks 19"
 - a 1 water cooler
- a Laser shoot :
 - a Digital signal TTL
 - a Effect on Pockels cell
 - a Mechanical shutter for security
 - a Shoot is Ok for the first pulse
 - a OFF immediate when signal is deactivated
- a Signal "Laser Ok"
 - a The most complet
- a Diagnostic :
 - a 2 connexions oscillo for maintenance
 - a Nor parameter filling nor diagnostic by serial communication
- a Security :
 - a Security "hard" that shut down everything
 - a Necessary to reinitialise the laser (with key, etc...)
 - a Necessity
 - Mechanical shutter
 - One complementary security for up/down loading
- a Operational Temperature:
 - a 20°C +/- 2°C
 - a to be extended
 - a to be validated in WP6
- a Starting / re-initialisation :
 - a Key deported

Other elements for maintenance:

Possibility to download different signals:

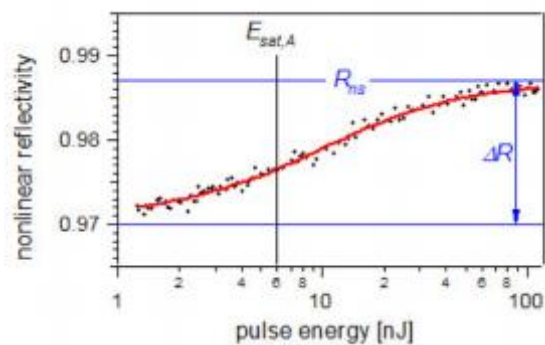
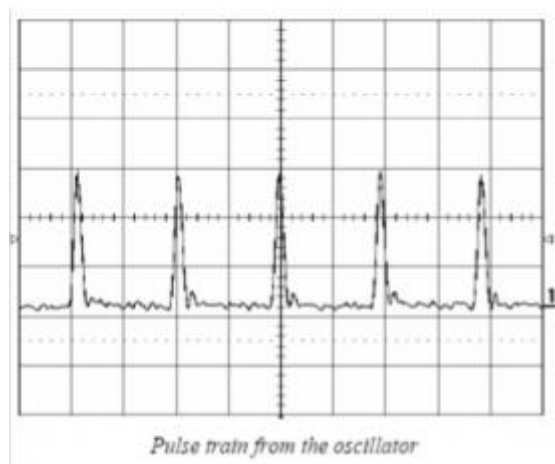
1. signal "external cooling problem" (T°, flow) => 1 signal output of water cooler
2. signal "diode problem":
 - » download one alarm to each diode pump (1 . 2 . 3) thanks to a photodiode
 - » measurement of a part of the output power of diode pump: comparison - calibration and current modification to increase lifetime of these pumps.
 - » other signals:
 - on-line calibration of the output power of the diode pump and iteration with diodes current,
 - periodic calibration of the output power of the laser and iteration with diodes current,.
3. Easy starting procedure for PLC.

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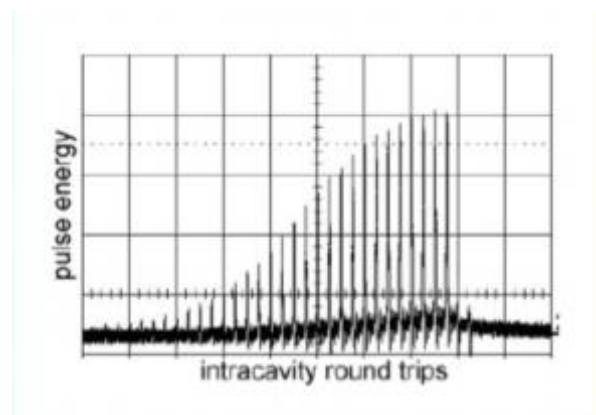
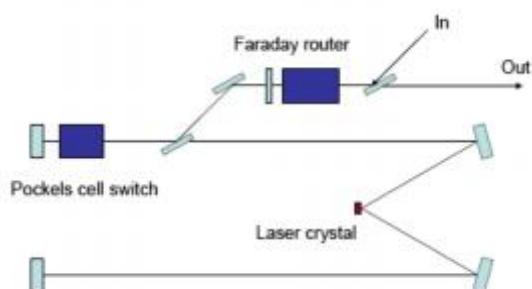
III.2.3 WP2.2 Construction of the prototype laser

Amplitude has manufactured the prototype laser, according to the characteristics in the design phase. They have experienced difficulties and supplier-related delays on several issues, for example in the realisation of the laser mechanical structure. Alignment and optimisation took also longer than expected. They have had to allocate significantly more resources, and expect a delay of approximately one month on the completion of WP2.2.


III.2.3.1 The oscillator



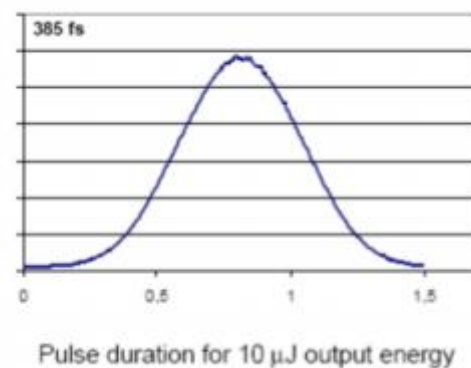
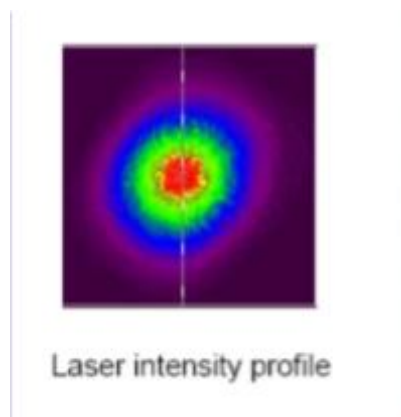
III.2.3.2 The amplifier



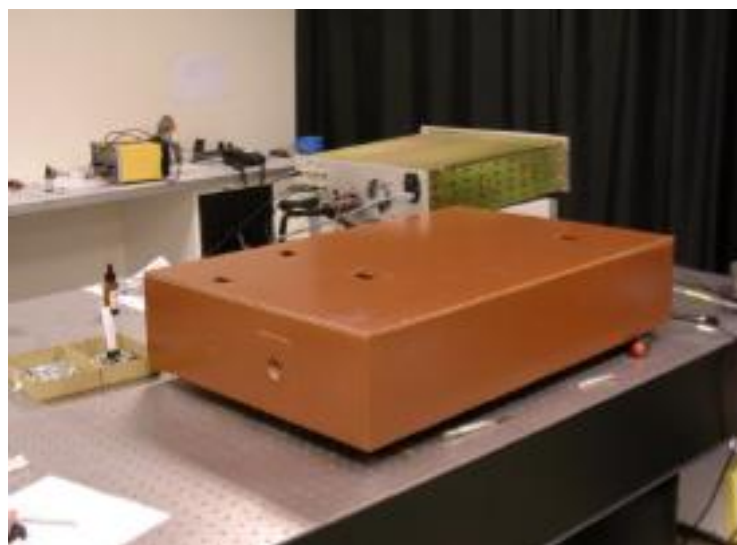
First optical performances are summarized in the table below:


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	Target	Results
Repetition rate	100 kHz	> 100 kHz
Pulse energy	10 μ J	10-15 μ J
Pulse duration	< 500 fs	< 400 fs
Beam quality	TEM ₀₀	TEM ₀₀



The laser met the design objective, and was transferred to LASEA within October for further testing, and integration in the complete system (WP4).



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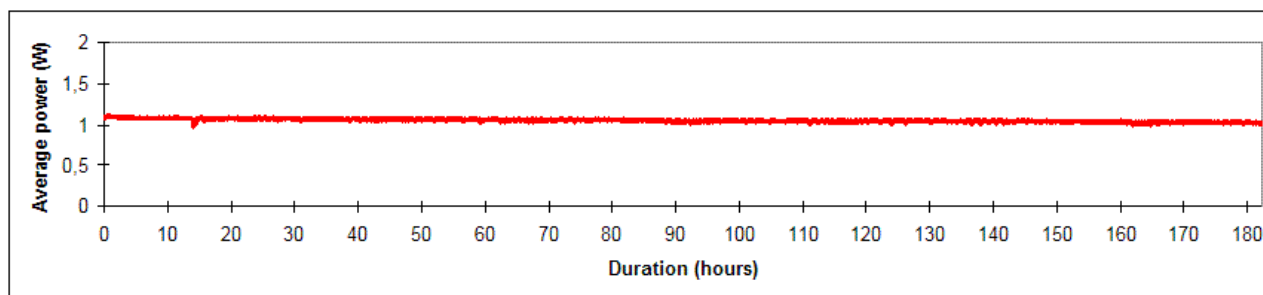
III.2.4 WP2.3 Validation of the prototype laser performances

Additional tests on material samples have been performed in the PALA laboratory in September 2005 to prepare for the integration of the prototype in the experiment set-up on WP4. Tests have allowed to validate important points in terms of laser interface, as well as the beam delivery line of the WP4 set-up.

A part of this work package was spent on a meeting in Bordeaux on 14/06/05 in Amplitude installation with all the partners.

The second part of this work package will be spent on the new laser source (s-Pulse HR laser) testing.


During the final optimisation of the system, we have performed in depth adjustments and measurements, to achieve all laser performances, as well as quality control and long term measurements on the laser. See in appendix the performance datasheet measured before shipment to LASEA.



Long term stability measurement

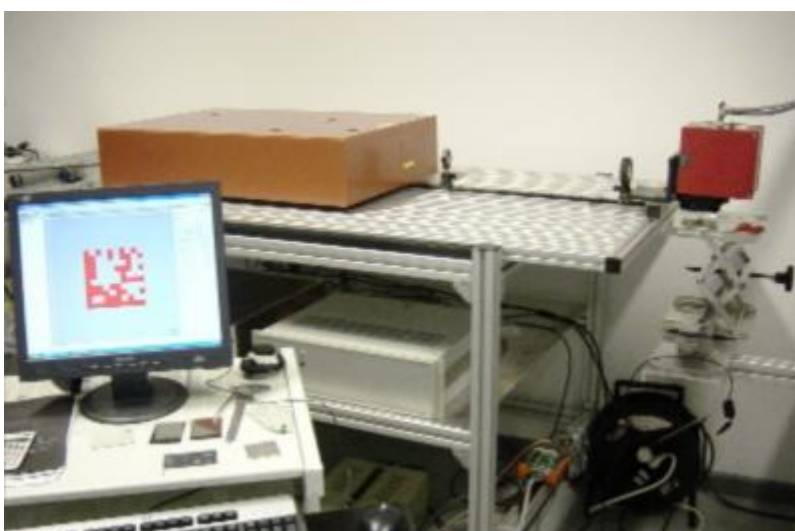
III.2.5 WP2.4 Support for the integration of beam control unit

The laser was shipped to LASEA on October 2006. Installation was carried out by representatives from Amplitude Systèmes, Lasea and KST. Initial acceptance tests were performed on a standalone optical bench, where laser performances were assessed, and the correct operation of the system was validated. Initial tests were carried out with the optical system available in Lasea.

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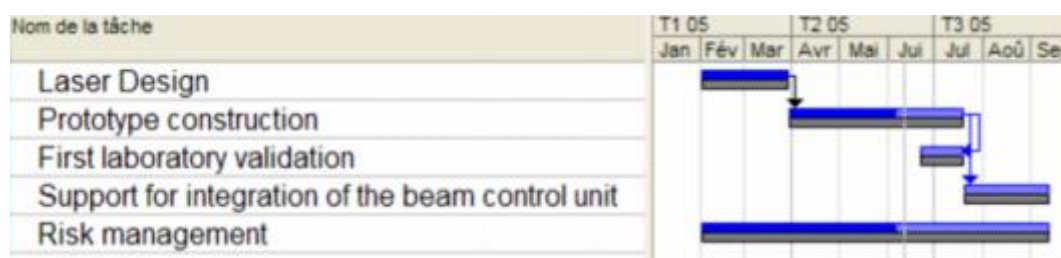
First datamatrix obtained in Lasea with the Naginels Laser




Laser system during installation at LASEA

III.2.6 WP2.5: Risk management of the work package

Amplitude have set-up an internal project review committee, whose responsibility is to ensure that the performance of the laser is in agreement with the desired specifications, and to guarantee that the laser is ready for operations at the specified time. We have encountered several problems in the optical design phase, as well as the mechanical engineering phase. For instance, thermo-mechanical simulations in the design phase have led to significant design changes, and supplier's delays have put strong constraints during the manufacturing phase of the laser.



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III.2.7 Conclusions

The WP2 meeting was held in Bordeaux on the 14th June 2005.

The final specifications for the laser have been greatly improved compared to the initial NAGINELS target (for instance, the laser speed has been increased by a factor of 10, from 10 kHz to 100 kHz). This required that we allocate more resources to the design phase than initially foreseen. Also, we have conducted thermo-mechanical simulations for the mechanical engineering of the laser, including finite element analysis computer runs, which also required more resources.

Amplitude has experienced difficulties and supplier-related delays on several issues, for example in the realisation of the laser mechanical structure. Alignment and optimisation took also longer than expected. We have had to allocate significantly more resources, but we have had a delay of approximately one month on the completion of WP2.2.

The second part of the validation of the prototype laser performances (WP2.3) and the support for the integration of beam control unit (WP2.4) was performed in Lasea during the second year. The results are detailed in the following workpackages.

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III.3 WP3 Development and validation of the control and vision unit


III.3.1 Work package flow chart

The Work package objectives are:

- a To design a laser control unit which will meet the productivity performances as set in WP1
- a To validate the performances of the laser control unit using first a YAG lasers
- a To design a vision system based on tests and samples made in WP1

The Work Package WP3 begun the 1st November 2005, before expected initially because, following the first conclusion of SMEs, potential end-users will focus on anticounterfeiting and normative applications. Reading system will be for these applications a key unit of the whole process.

- The SMEs companies, mainly Solos, have had to detail the specifications of the new vision system. KST help Lasea in the communication interface of the system (Ethernet).
- Test phase and optimizing the reading system were obtained thanks to WP1 samples and new WP3 samples.
- The SMEs companies have had to detail the specifications of the control unit regarding the functional requirements. Pala and CSL help Lasea for the development of Optical systems.
- Different optical systems were developed and tested during the last part of WP1.
- The first elements were shared during the WP1 meeting that took place the 15th February 2005. First demonstration of vision system was made.
- KST worked especially on the specifications for communications between the control system and the laser source, and developed a new interface for vision system and control unit (communication between sub elements and MES).
- The final specifications for the vision system have been greatly improved compared to the initial NAGINELS target (High contrast grade A – AIM).
- A midterm meeting took place in Liège on 12th July in Lasea installation with all the partners to review the key parameters. The prototypes of control unit and vision system in a laboratory scale were shown.
- The validation of control unit has to be done with the new laser. Seeing the delay on this element. Tests have been made with YAG laser in order to check process speed

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of the control system and with fs laser in Pala laboratories in order to check new optical systems.

- Samples made during this last test campaign in Bordeaux validated the final vision system.
- In the second year, Lasea, Amplitude and KST worked together in order to optimise all the connections and communications between the laser and its control system. Following the work carried out under WP2, various interfaces between the laser and the control units have been optimised.

All the elements of the control unit and vision system will be summarised in the deliverable 3.1 (26p), sent to the Commission in December 2005. It is divided in 3 main parts:

- » Chapter II: Design of the engraving control unit p 4
- » Chapter III: Development of the vision system p 18
- » Chapter IV: Validation of the performances of the control unit p 22

The main points of these reports are summarized in the following task descriptions.

III.3.2 WP3.1: Design of the engraving control unit

The engraving control unit is divided in two main parts:

ü The transport of the beam on the substrate to be engraved

This part is divided in three subsystems:

- The Galva head
- The optical system
- The Control card


ü The computer interface

This part is divided in two subsystems:

- PLC controller
- The Software

The new control system will have to respect the following constraints:

- *Not to create any microcracks*
⇒ *Stable and defined laser power density*
- *Miniaturize the codes while maintaining a high level of information*
⇒ *Accuracy of the positioning*

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- To allow high speed process
 - High speed positioning, high translation speed of the beam

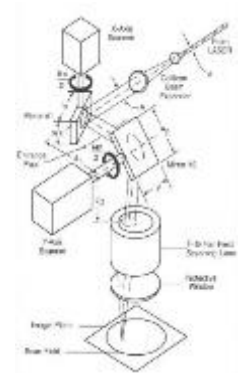
The Datamatrix code must also have a variable position according to samples. The area covered by the laser must thus be large enough to make the code undetectable. The target of the design was to respect the following specifications:

- a The laser beam must be focused on a surface lower or equal to 5 µm diameter
- a the scan area must be higher than 10 mm X 10 mm
- a a sub mm² Datamatrix have to be proceed in less than 0,5s

III.3.2.1 The galva head

Principle

The laser beam passes through a beam expander, which makes it possible to focus the beam on a smaller volume, then it is successively reflected by two mirrors controlled by rotary motors, which can deviate the beam on both X and Y axis. the beam is finally focused by a lens in order to increase the power density of the laser radiation.



Beam expander :

For a precise material treatment, the focal spot must be minimized. This spot size is given by the following formula:


$$d_f = \frac{4}{\pi} \frac{\lambda f}{D} M^2$$

with f the focal length and D the beam diameter before focusing.

So we can see that increasing the beam dimension D makes it possible to obtain a smaller focal spot.

The mirrors

When beam diameter is given, this value corresponds to the width of the beam at I_{max}/e^2 intensity. Thus when a beam is transmitted through a lens or is reflected by a mirror, dimensions larger than the beam diameter must be chosen not to cut a part of the radiation.

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The percentage of lost power for a lens or mirror diameter A is represented on the following table:

A/D	0.8	1	1.2	1.4	1.6	1.8	2
Loss (%)	27.8	13.5	5.6	1.98	0.6	0.15	0.03

In order to deviate the laser beam, the mirrors are linked to galvanometers (often abbreviated to galvo), which are devices able to move back and forth the mirrors several thousands of times a second.

The lens(es)

The lens is used to focus the laser beam. There are many kinds of lenses, from of a very simple design (spherical biconvex lens) to a very complex one with several elements.


In order to reach a focal spot diameter lower or equal to 5 μm , it is necessary to choose a right F/D couple. The following combinations have been tried during our experiments:

<i>F</i>	<i>D0</i>	<i>BE</i>	<i>D</i>	<i>F/D</i>	<i>lambda</i>	<i>M²</i>	<i>df</i>
100	3,5	8	28	3,57	1,03	1,1	5,2
75	3,5	6	21	3,57	1,03	1,1	5,2
50	3,5	6	21	2,38	1,03	1,1	3,4
50	3,5	4	14	3,57	1,03	1,1	5,2
25	3,5	4	14	1,79	1,03	1,1	2,6
12,5	3,5	4	14	0,89	1,03	1,1	1,3
25	3,5	2	7	3,57	1,03	1,1	5,2
12,5	3,5	2	7	1,79	1,03	1,1	2,6
12,5	3,5	1	3,5	3,57	1,03	1,1	5,2

Simple lenses with these characteristics are very easy to find on the market, however performances of simple lenses are limited by their aberrations. To achieve better optical performance, multi-element lens designs are required. A multi-element lens uses a combination of various singlet elements to minimize the overall aberrations.

Different configurations were tested theoretically (Ray tracing) or experimentally (with fs laser at PALA laboratories or with ns laser at Lasea laboratories):

- a Achromatic doublets
- a Cooke triplet lenses
- a Achromatic doublet with matching
- a Double Gaussian lens
- aplanatic meniscus lens
- a Reverse telephoto lens
- a Symmetric lens pairs
- a F-Theta Lens

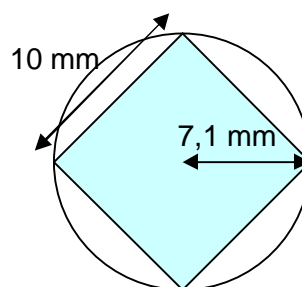
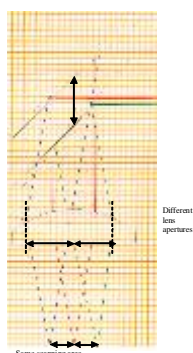
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Lasea has explored the different possibilities. The tests were done thanks to PALA equipments with fs laser and thanks to YAG equipments (see WP3.5). Lenses used in these experiments came from PALA, Lasea and CSL.

Scanning area

The scanning area is calculated with the formula $y' = F \tan(\theta)$ or $y' = F\theta$ according to cases. Thus for an angle of the mirror of 10° compared to its original position, the beam is deviated of 20° compared to the lens normal and moves of 8.7 mm for an F-Theta lens of 25 mm of focal length, and 9.1 mm for a simple lens.

It should be noted that the distance between the second mirror and the lens does not have any influence on the scanning area but it must be minimized in order to reduce the aperture of the lens, as it is illustrated on figure below.




⇒ To have a scanning area of 10 mm x 10 mm, the beam must be moved of $5\sqrt{2}$ mm, that is to say 7.1 mm.

Although F-Theta lenses are the best lenses for our application, only focal lengths higher than 100 mm are available (except for the three companies which propose F-Theta of 60 mm of focal length). One of these lenses will be chosen for the definitive prototype, as soon as the new fs laser source will be at Lasea and tested with the control system.

III.3.2.2 The control card

The galva head will be controlled by an electronic card to be placed in the computer. This card will be linked to the PLC to manage the laser source and with the graphic software.

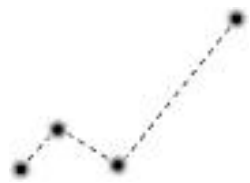
The designs we make in Naginels project are very small and require a very high accuracy. The accuracy will depend of the galva head and of the control card. Some galva head and control card have bidirectional communication in order to increase the accuracy thanks to a

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feed back signal on the mirror position. The actual control card has this bidirectional communication but we are checking to have a cheapest system without the return signal.

The accuracy will also depend of the scan command waveform given by the control card. They can be separated into three broad categories: step, raster, and vector. The required waveform type is determined by application requirements. Each waveform type has particular scanner performance characteristics and specifications associated with it.

Step Scanning



The term step scanning is used when the mirror is moved rapidly from one position to another and the optical system is being utilized only at the ends of the motion. The path traveled between the two end positions is not important to the application.


A scanner step response is considered complete when the scanner enters and stays within the settling tolerance, centered around the final position. The step time is measured from initial scanner motion to the time at which settling tolerance is achieved.

When a scanner is being commanded to a constant position, such as at the beginning or end of a step, the mirror will still be moving slightly, due to noise existing in the scanning system. This noise motion is referred to as dither.

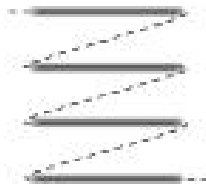
When a scanner is commanded to return to the same position as part of a series of steps, the consistency with which the scanner returns to this position is referred to as repeatability. This is a more specific parameter than accuracy, which includes other factors such as initial calibration, thermal drift, and position detector non-linearity.

Wobble, or non-repeatable cross axis motion of the mirror (discussed under Raster Performance, below), must also be considered in some stringent step-scanning applications.

- a This scan command waveform is the more accurate but will be only useful for very small Datamatrix, because it will be not possible to benefit from the high repetition rate of the laser source and because the design has to be made “point by point” requiring a longer process time.

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Raster Scanning



In raster scanning, the mirror is swept at a constant velocity over a fixed angular range in a repetitive manner. At the end of the each linear sweep the scanner reverses direction, returns to the starting position and repeats the scan.

Velocity non-linearity is a measure of the repeatable non-uniformity of velocity during the active scan time, and is typically expressed as a percent of nominal velocity. **Jitter** is a measure of the non-repeatable velocity perturbations, and is generally specified as the standard deviation of the error between expected and actual mirror position during the active scan. During the active scan, the scan mirror experiences some non-repeatable motion in the axis perpendicular to the scan axis. This motion is referred to as scanner **wobble**.

- a This scan command waveform is the more adequate for the creation of diffractive structures forming the high contrast design shown in WP1 samples. Wobble and jitter have to be controlled in order to have a fine repetitive pattern and maximizing the diffraction order. It's also the best waveform to benefit from the high repetition rate of the laser source


Vector Scanning



In vector scanning the command waveform is structured as series of small steps, updated at a rate beyond the scan system bandwidth. This enables the scanner to maintain a constant velocity while the laser is on, and to settle uniformly following repositioning moves with the laser off.

The **acceleration time** is the time between the initiation of a constant velocity command and the scanner achieving this commanded velocity. **Lag time** is the delay encountered during constant velocity operation. It is the time between when a given position is commanded and when the scanner actually achieves this position. The **tracking error** is the angular error between the commanded and actual positions during a constant velocity scan.

- a This scan command waveform is the more adequate for the engraving of complex designs and will benefit from the high repetition rate of the laser source. Unfortunately, the command of the laser firing will have to be very fast seeing the

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high repetition rate (100kHz). Tests have to be done to optimise these commands as soon as the new laser source will be integrated with the control system developed.

The accuracy of all scan waveform types is affected by thermal drifts of the scan system and, these drifts should be considered during system validation.

⇒ Another possibility with a 3 axis scan head has also been evaluated.

III.3.2.3 The price study

Four suppliers and 7 configurations have been evaluated in term of price and performances. In addition of price level, the following elements were taken into account:


Galva head & control card:

- | | |
|----------------------------------|---|
| a Aperture | a Possibility to mark on the fly |
| a Beam Displacement mm | a Compatibility with marking software |
| a Dimension mm | a Flexibility of the parameters & calibration |
| a Marking speed | a Flexibility of optical system modifications |
| a Positioning speed | |
| a Writing speed good quality cps | |
| a Writing speed high quality cps | |
| a Typical Scan Angle [rad] | |
| a Tracking error [ms] | |
| a Long-term drift 8 hours [mrad] | |
| a Nonlinearity [mrad] | |
| a Repeatability [μrad] | |
| a Weight [kg] | |

III.3.2.4 The control interface

To develop the control interface, KST and Lasea have worked on:

- ü Functional description of the required interface.
- ü Safety concept required by such technology.
- ü Interface technology analysis: check of the 'interface concept' in term of:
 - » Openness: connectivity ...
 - » Value of the approach in a more 'global concept'.

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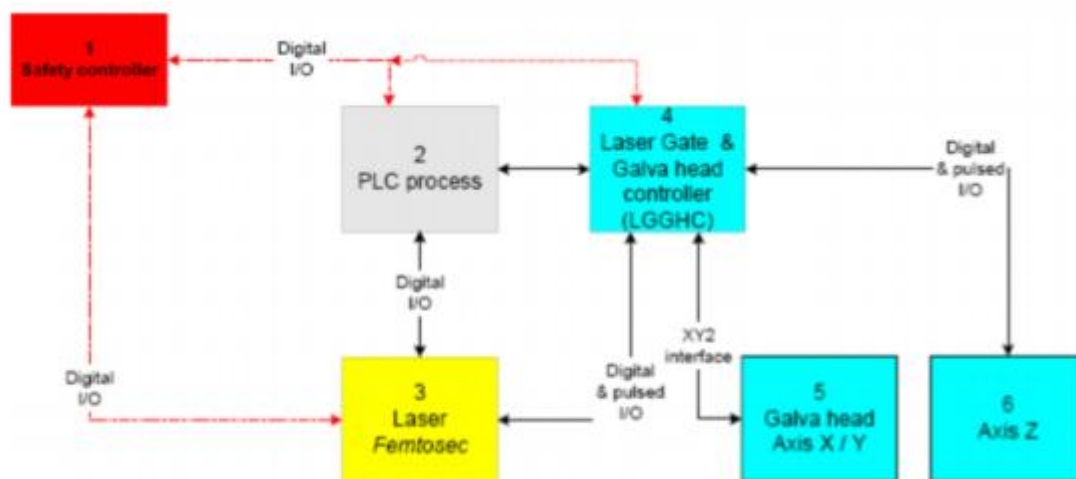
III.3.2.5.1 context

The NAGINELS technology provides an alternative and innovative laser solution in subsurface glass engraving. This technology covers decorative, anticounterfeiting and normative applications. The femtosecond laser source developed by Amplitude is a laser pumped by diodes which, in compactness, delivers short impulses of strong energy at high rate. To integrate correctly this technology in such defined ‘NAGINELS’ environment, it’s required to define and execute an interface that can grant a safe, accurate and flexible use of the laser.

III.3.2.5.2 Functional description


LAYOUT

Such interface can be described as follow:



DESCRIPTION

1. A safety controller take is used to eliminate all the risks inherent to the laser technology (see next paragraph).
2. A Process Logic Controller (PLC) is used as the basic interface between the ‘external process’ and the laser and associated equipment. This PLC can define a secure and powerful ‘process phased’ and interlocked logic which interact on all the other equipment.
3. A femtosecond Laser is the used as the laser source.
4. A specific controller (LGGHC) take in charge all the synchronisation between the Laser pulsed source (GATE) and the galva heads which place the ‘pointed –

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engraved' piece in an exact X Y Z position. So, an accurate laser shooting can be executed.

5. X Y galva heads perform the axis X Y positioning of the 'pointed – engraved' piece.
6. Z actuator performs the axis Z positioning of the 'pointed – engraved' piece.

SAFETY CONCEPT

REVIEW OF RISKS

Laser risks

Though the average power of the laser used for this application is low, its peak power is very high and it must be considered as a dangerous laser, emitting visible and invisible radiation which can cause severe eye injury. According to the European safety standard (IEC 60825-1), it is a "Class 4" laser, which means the most dangerous ones. In terms of machine safety, this hazard is considered as a "Category 2" only device (it is not lethal and the probability to be hurt is very low).

Mechanical risks

Integrated in a process, this equipment will be linked with moving parts (rotating table, automatic doors,...). In terms of machine safety, this hazard is considered as "Category 3". But 'outside the process', the different components described hereunder must not be considered in a point of 'mechanical risk'.

Electrical risks


Like any electrical machine, the 'NAGINELS Laser & associated equipment' presents dangerous voltages. The electrical cabinet / boxes must be classified in IP2x category and their access is limited to qualified technicians. A particular care must be taken for laser maintenance because the technician will access high voltage (several kV) connections.

Fire

There is no particular fire hazard.

Glass injury

Finally, we just mention that working with glass always represents some danger and that the normal safety regulations should be observed (safety glasses, other personal protections...).

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MANAGEMENT OF SAFETY

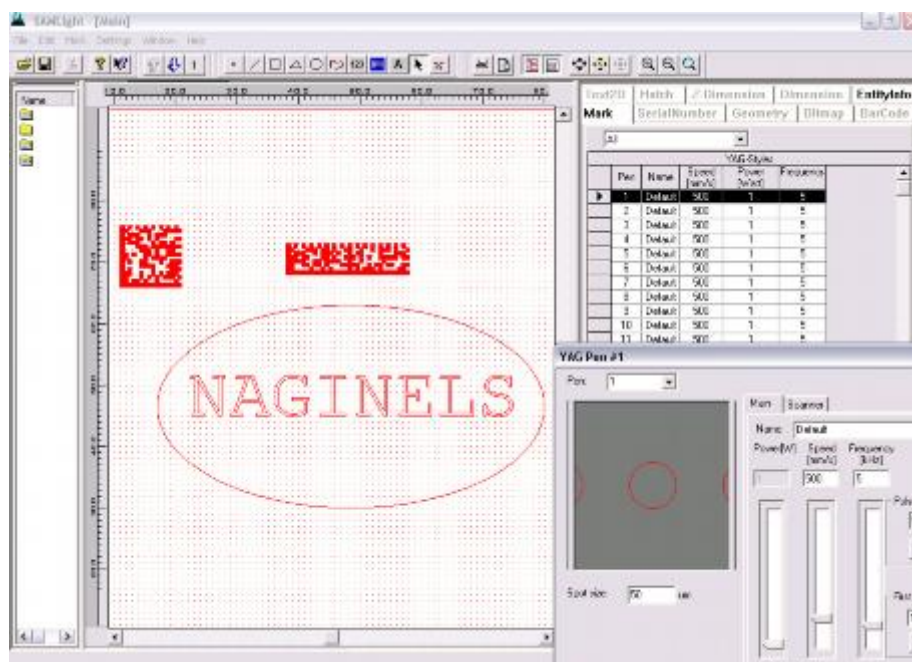
One safety controller takes in charge the safety management.

The target of this controller is:

- ü • To stop the process in case of:
 - » Operator action (Operator's Emergency Stop).
 - » Severe alarm configuration (Emergency Stop logic engaged by the PLC or the LGGHC or the Laser).
- ü • To validate the start of the process (Operator's action required before any Start).


III.3.2.6 The software

Lasea has tried and validated several software to control the galva head.



The main software features are:

- ü runs under windows 98/ME/NT/2000/XP
- ü multi-language support with an integrated resource editor
- ü fast rendering of graphical data with mouse and keyboard input
- ü property page concept for fast adjustment of pens, hatch parameters...
- ü entity list for defining the mark order
- ü remote control via ethernet or direct program calls
- ü support different scanner driver cards
- ü variable adjustment of laser and scanner parameters

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ü scanner movement preview

ü generation of text

- linear and radial text
- windows true type fonts
- serial numbers
- customised date/time object
- laser fonts
- fonts editor

ü generation of 1D & 2D code

- different format of 1D code : code39, EAN, EAN-128,UPC-A, data matrix...
- Extended datamatrix ECC200 access mode
- Datamatrix dot generation

ü Generation of bitmaps

- Generation of markable scanner bitmaps
- Dithered and grey scale marking

ü Multi-scanner head management

ü Management of 3D optics


III.3.2.7 Interaction with other subsystems

The interactions with WP2 and WP5 are high, and strong link have been created between the Amplitude, Lasea and KST technical teams:

Amplitude has evaluated with Lasea the influence of the basic laser design parameter (oscillator or amplifier) on the control unit design.

KST and Amplitude have studied with Lasea the synchronisation requirement, the beam characteristics, the mechanical interface, and the diagnostics required.

A mid-term meeting took place in Lasea on the 12th July 2005 with all the partners.

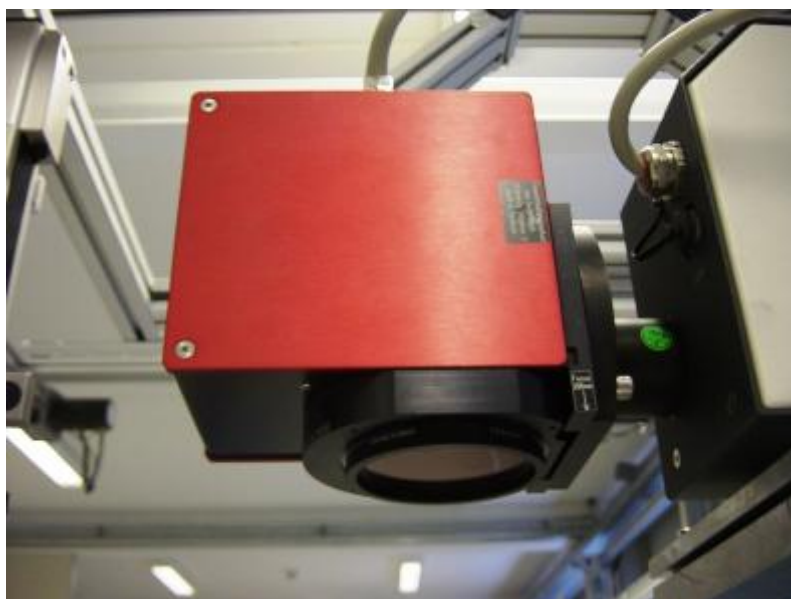
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III.3.3 WP3.2: Construction of the control unit

Lasea has manufactured the prototype control unit, according to the characteristics in the design phase. Seeing the high level of dependence of the control part (Control card, Galva head & optical system) and the laser source, this first prototype system has a lot of flexibility but will be perhaps not adapted to match all the specifications for each application.


- a The high resolution (codes < 60µm) can be achieved with one special optical system using a microscope objective but allowing a rather small field size (1,5mm x 1,5mm).
- a The medium resolution (codes > 100µm) can be achieved with one special f-theta optical system, allowing a larger field size (10 x 10mm).
- a Larger field size and better resolution will lead to highest Galva head aperture and thus problems for marking speed, seeing the weight of the mirrors.

Definitive card, Galva head and optical system have to be checked with the new laser source. Seeing the delay on the delivery of the laser source (see WP2), modifications may be necessary on the prototype during the validation tests (to be performed in November)



In order to check sub elements performances, Lasea has made:

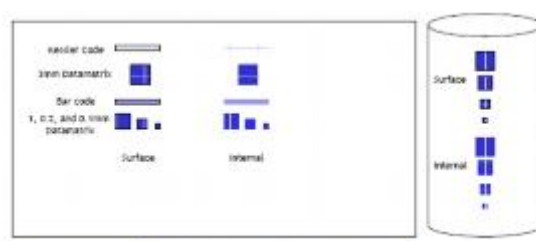
- a tests in Lasea to check the performances of the Galvahead and control system with a 100kHz YAG laser (see WP3.4).
- a tests in PALA to check the new optical system with a fs laser

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Details of the optical system validation in PALA.

This 5th test campaign in PALA consisted in engraving tests using the new optical system and PALA's femtosecond laser (model s-Pulse, wavelength 1030nm, average power 1W, repetition rate 1-10 kHz). The new optical system, susceptible to be integrated in the future laser engraving machine, is a good compromise between high output numerical aperture and large field. The first aim was to compare results obtained during the four previous test campaigns with other lenses (f-thêta lens 88 mm, video objective 12 mm, 16 mm, 25 mm, and high aperture objective 17 mm) to the results obtained with this new optical system. The second aim was to produce samples for end-users company (COSTET, TBS, SOLOS). More than 200 micro marking (both surface and intra-volume marking) were achieved: square, text, barcode, datamatrix, grating. Engraving tests, like, were performed on flat glass and on bottles. Intra-volume markings were done 500 µm under the surface. Contrast and quality of those marking meet the requirements of the three targeted applications (antifraud or anti-counterfeiting, normative marking, decoration).


The new optical system was also characterized thanks to PALA and Amplitude equipments.



Grating at 5mm.s⁻² and 1mm datamatrix



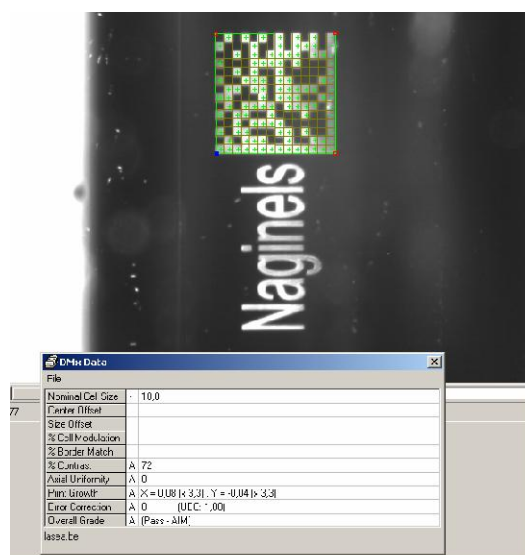
200µm and 100µm datamatrix with cross-hatch engravings

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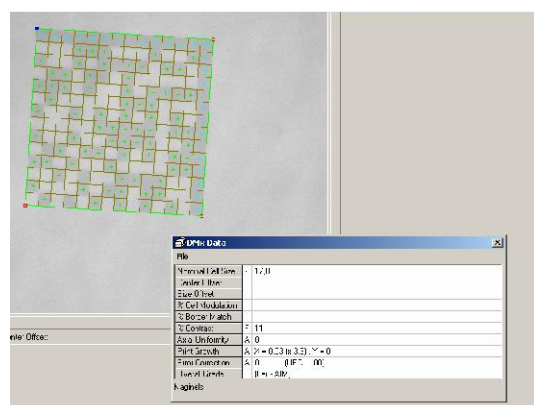
III.3.4 WP3.3: Development of the vision system

III.3.4.1 Introduction


The development of the vision system begun in November 2004 (well before initially expected) because seeing the very good results of WP1, it seems necessary to validate also the readability of the codes engraved. More than 80 reading tests have been done on samples of WP1 to design the reading systems. Flexible systems were developed for the three processes (diffractive effects, colour change and structural change) (see details in Deliverable 1.1):



The **diffractive effects** allow a very high contrast (more than 72%!) and a perfect axial uniformity. This is a very good result for the future developments of the normative and anti-counterfeiting applications.



The **coloured changes** allow a lower contrast (10 – 15%) but a perfect axial uniformity. This effect will be use for anti-counterfeiting applications, but will be not contrasted enough for normative applications with a high speed automatic reading device after the marking process.

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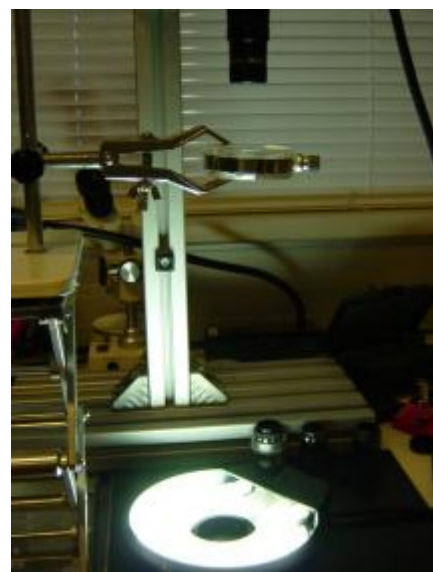
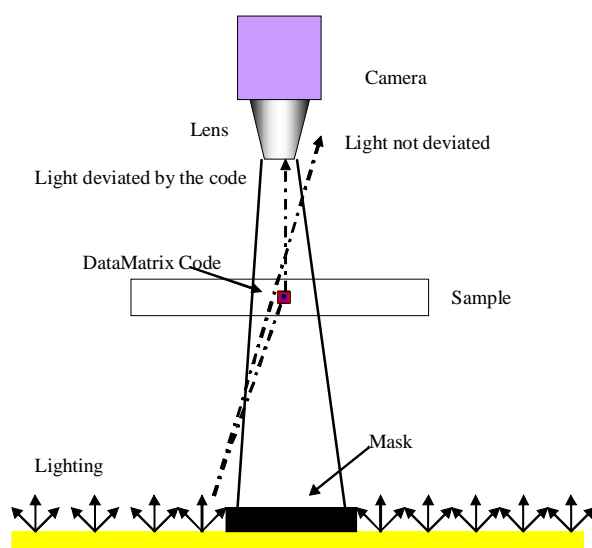
The structural changes allow a very high contrast (more than 76%!) and a perfect axial uniformity. This is a very good result for the future developments of the normative and anti-counterfeiting applications. The integrity of the glass (completeness of the product) is nevertheless not warranted. For pharmaceutical sector, diffractive structures will be privileged.


III.3.4.2 Understanding of key parameters to design vision applications

- § Datamatrix code & associated standards
- § CCD camera, Lens & Lighting

III.3.4.3 Equipments selection for testing session

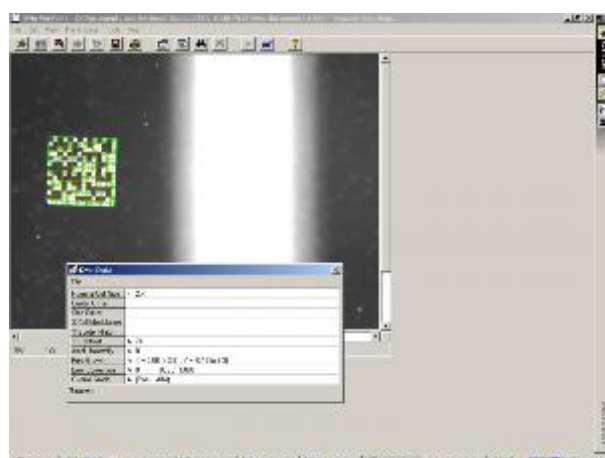
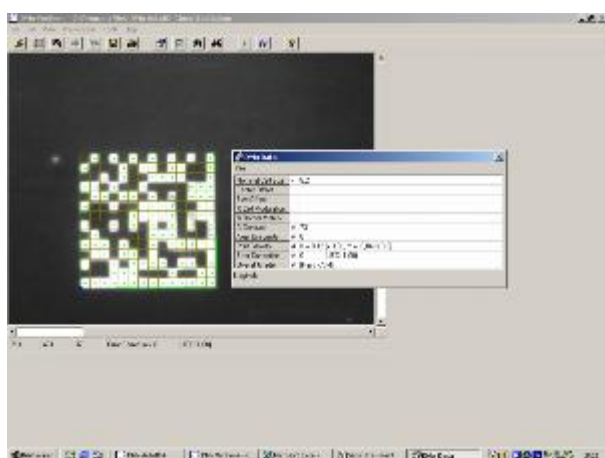
- § CCD camera of ½-inch, 1024x768 pixels
- § Lens : Macro Vario Lens with magnification from 0,8x to 4X
- § Backlight with masking (dark field technique)



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III.3.4.4 Testing

- § Reading test made on various glass types
 - Float glass
 - Syringe
 - Vials
 - Beverage glass (bottles)
 - Perfume bottles
- § Reading test made on various datamatrix size from 1x1 mm to 60x60 µm



III.3.4.5 Results – Main advantages

- § Backlight with a mask aligned with camera's axis is the optimum lighting solution to read datamatrix codes made by structural change & refractive index change
- § Marking by structural and refractive index change give the best results in terms of reading performances.
- § Datamatrix code from 1x1 mm to 60x60 µm are readable
- § One CCD camera mounted with one special lens can cover datamatrix size from 1x1 mm to 60x60 µm


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III.3.4.6 Results – Limitations

- § Marking by change of colour allows reading datamatrix code for anti-counterfeiting applications but low contrast value is a limitation for normative application.
- § With the lighting technique used, any pollutants, particles, surface texture generate image perturbation. This effect increase as the size of the datamatrix code decrease.
- § A particular attention is necessary for the positioning of the samples in front of the camera as the depth of view is decreasing with datamatrix size.

III.3.4.7 Final validation with samples of WP3.2



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III.3.5 WP3.4: Validation of the performances of the control unit

This task allows the validation of the performances of the control unit with a YAG laser. Before the specific experiments of WP3.5 and WP4, we use a YAG laser to validate the control system (software, galva head and optical system). Even if the results cannot be applied directly to the fs system, it was useful to test the functionalities of the software, the accuracy of positioning of galva head, and the control of a 100kHz laser.

We made tests in Pala to validate optical systems because these parts are very depending of quality of laser beam and special pulse duration (size of the engravings are very different from YAG laser and process is completely different). Unfortunately, it is not possible to test there very low step between lines (due to the software), process time (due to very heavy mirrors and computer calculus time). So the two tests (in PALA and Lasea) were necessary and complementary.

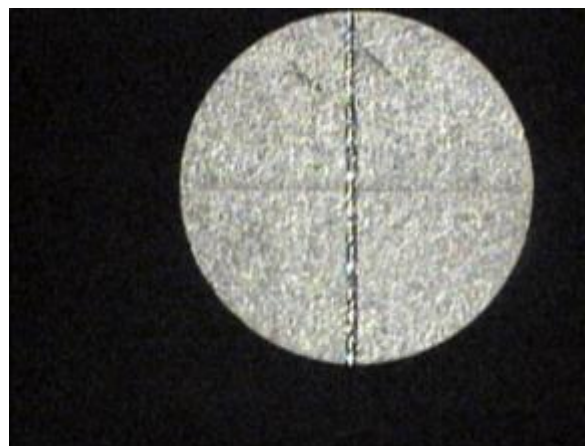
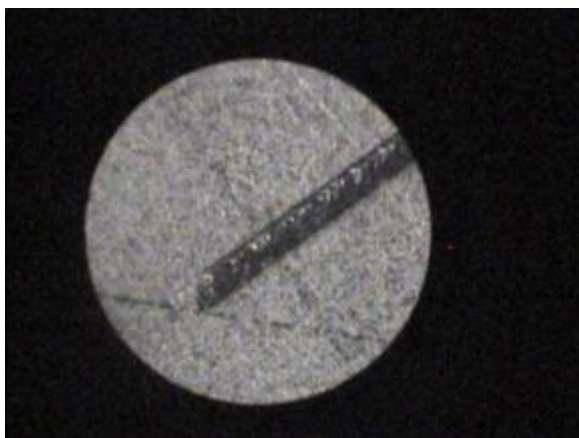


YAG Laser used in this task


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Comparison of process time (1 – 10 – 100kHz) * top quality with the optical system

Time (s)	DM 1mm	DM 200µm	DM 100µm	DM 60µm
1kHz (Lasea)	70,2	3,2	0,35	0,23
1kHz (PALA)	225	22,2	10,4	
10kHz (Lasea)	7,88	0,54	0,1	0,087
10kHz (PALA)	33,7	4,3	2,3	
100kHz (Lasea)	1,64	0,274	0,075	0,07
Relative time				
1kHz (Lasea)	100,00	4,56	0,50	0,33
1kHz (PALA)	320,51	31,62	14,81	0,00
10kHz (Lasea)	11,23	0,77	0,14	0,12
10kHz (PALA)	48,01	6,13	3,28	0,00
100kHz (Lasea)	2,34	0,39	0,11	0,10



Check of the step of 4µm with new software, galvahead and optical system (YAG laser)

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III.3.6 WP3.5: Evaluation of the key engraving characteristics using the prototype femtosecond laser

In this task, Lasea made the first tests with the new laser. Issues and key engraving characteristics have been evaluated (See WP4). Then, Lasea, Amplitude and KST worked together in order to optimise all the connections and communications between the laser and its control system. Following the work carried out under WP2, we have optimised the various interfaces between the laser and the control units.

III.3.6.1 Laser synchronisation

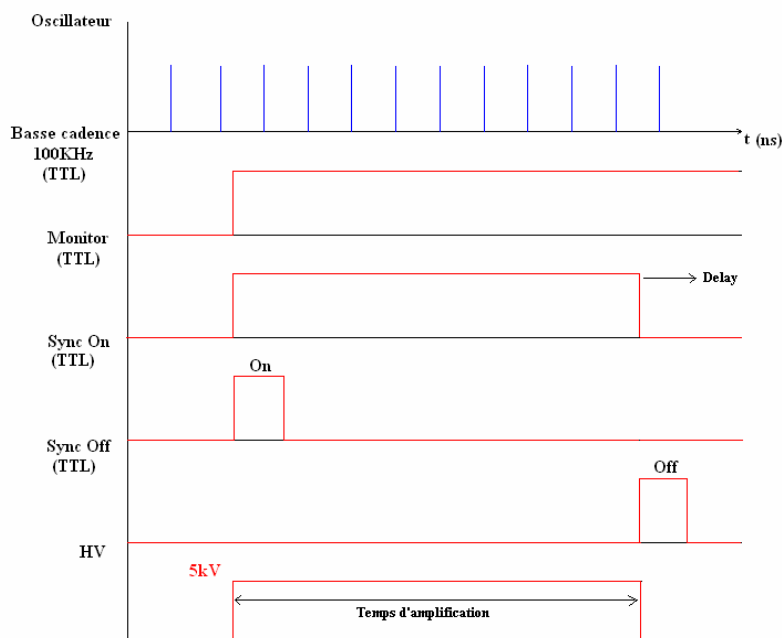
III.3.6.1.1 Introduction

The synchronisation unit controls the following functions:

- Regenerative amplifier electro-optical switch.
- Electro-mechanic beam shutters in the laser head.


III.3.6.1.2 Time diagram

An electrical signal is generated, which is synchronised with the oscillator pulse train.



Timing diagram

- The Oscillator signal is provided by a fast photodiode and has a typical repetition rate of 50 MHz.

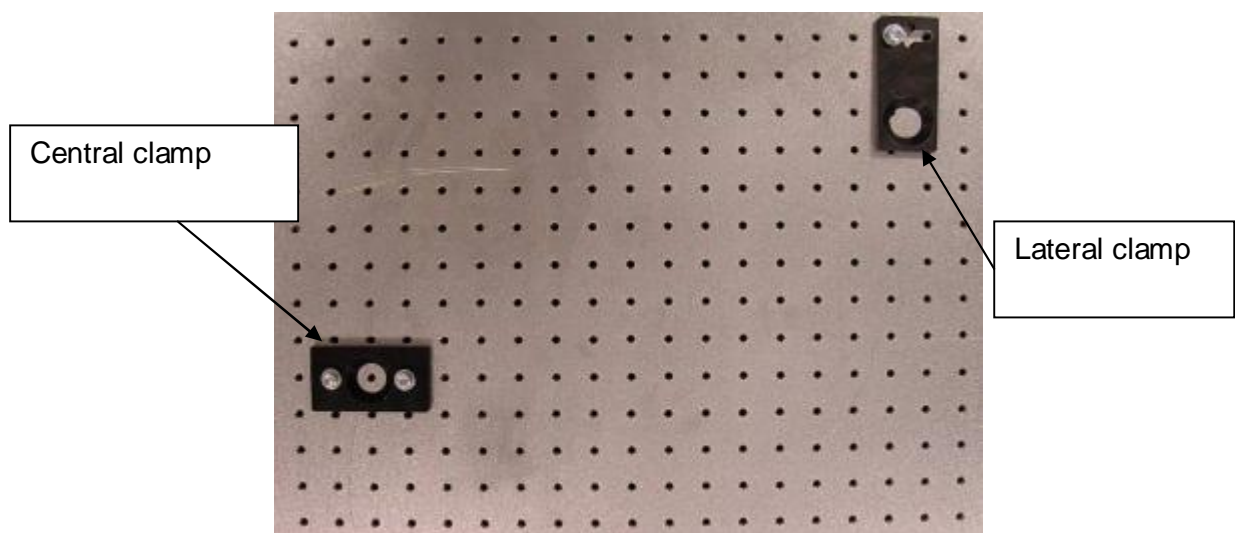
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- The Low Frequency ("Basse cadence", BC) signal has a repetition rate equals to the laser repetition rate, i.e. 100 kHz for the Naginels laser.
- The signals « Sync On » and « Sync Off » are provided via the synchronisation of the "BC and "OSC" signals.
- The HV signal is the high voltage applied to the electro-optic switch inside the laser.
- The Monitor signal is a direct TTL image of the high voltage pulse in terms of synchronisation .


III.3.6.2 Laser interfaces

III.3.6.2.1 Mechanical interface

The laser head must be positioned on a flat and stable surface, ideally an optical table. In order to avoid mechanical stress to the laser housing, the following mounting mechanism is chosen using the two provided mechanical supports: the central foot of the laser is fixed in a truncated cone and one of the two other feet in an oblong hole (see figure 6). A third mechanical support can be used, square one, which has to be kept free (not fixed to the table).

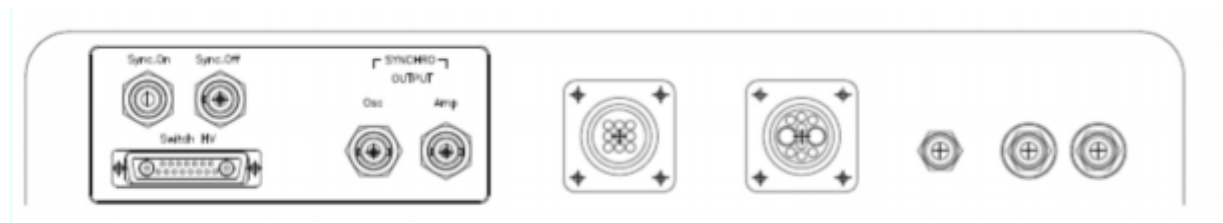


Mechanical interface

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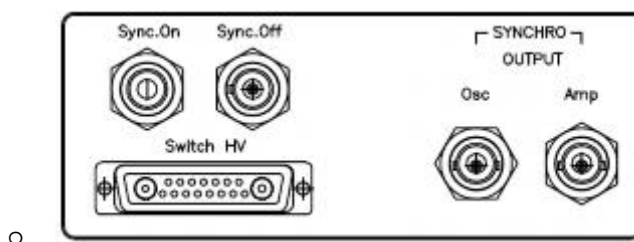
III.3.6.2.2 Electrical interface

The following figures present the available electrical interfaces on the laser head:




Electrical interfaces

- 9 pins connector: Laser head diagnostics.
- POWER SUPPLY connector: This 10 pins connector carries the following signals:
 - Laser diode current
 - Laser diode temperature measurement
 - Interlocks loop
 - Ground
 - Diagnostics power supply



Interface detail

- OSC connector : An internal control photodiode provides an electrical signal monitoring the pulse train from the oscillator. This signal is sent to the RF IN input of the synchronisation module.
- AMP connector: An internal control photodiode provides an electrical signal monitoring the pulse train from the regenerative amplifier. This signal is available to the user.

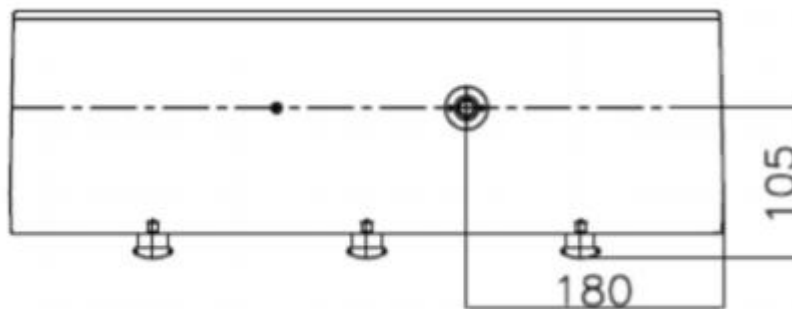
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- Switch HV connector: This subD connector carries the DC high voltage and low voltage signals for the high voltage electro-optic switch located inside the laser.
- Sync ON connector: This connector receives the TTL trigger signal for the high voltage electro-optic switch located inside the laser.
- Sync OFF connector: This connector receives the reset signal for the high voltage electro-optic switch located inside the laser.


III.3.6.2.3 Optical interface

The beam height, referenced to the base of the laser housing is 105 mm. The beam height referenced to the internal base of the laser is 35 mm.

The nominal output beam location is shown on the following figure:



Interface optique

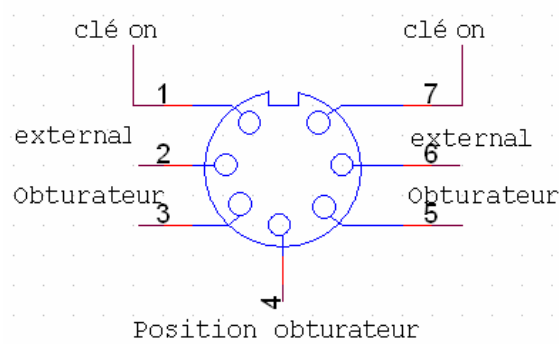
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III.3.6.3 Interface with the control unit


III.3.6.3.1 Interlocks

Two connectors allow interaction between the laser and the control unit.

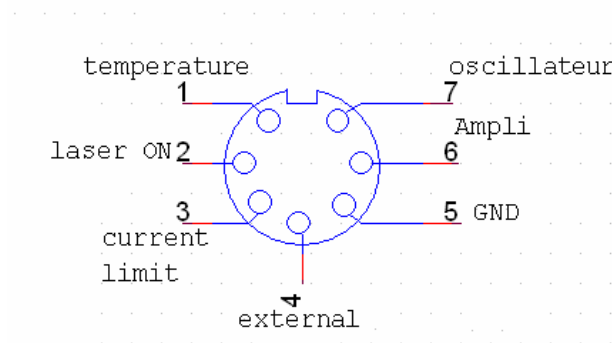
Interlock 1




- On key: A dry contact between pins 1 and 7 starts the laser diode current supply. This contact is in series with the front panel key of the power supply.
- External : A dry contact between pins 2 and 6 interrupts the laser diode current supply in case of a safety fault. If this contact is open, the diode power supply is switched off.
- Beam shutter: This dry contact between pins 3 and 7 controls the electro-mechanical beam shutter located inside the laser. If the contact is closed, the beam shutter is open.
- Beam shutter status :
 - « +5 V » shutter closed
 - « 0 V » shutter open

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Interlock 2



- Température : Pin 1 supplies the status of the laser diode temperature interlock:
 - « 0 V » interlock OK
 - « +5 V » interlock fault
- Laser ON : Pin 2 supplies the status of the laser diode current
 - « 0 V » current off
 - « +5 V » current on
- Current limit : Pin 3 supplies the status of the laser diode current interlock:
 - « 0 V » current off
 - « +5 V » current on
- External : Pin 4 supplies the status of the user interlock
 - « 0 V » current off
 - « +5 V » current on
- Ground : Pin 5
- Oscillator : Pin 6 supplies the status of the femtosecond oscillator
 - « 0 V » oscillator fault
 - « +5 V » oscillator OK
- Amplifier : Pin 7 supplies the status of the femtosecond amplifier
 - « 0 V » amplifier fault
 - « +5 V » amplifier OK

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III.3.6.3.2 « GATE » operation

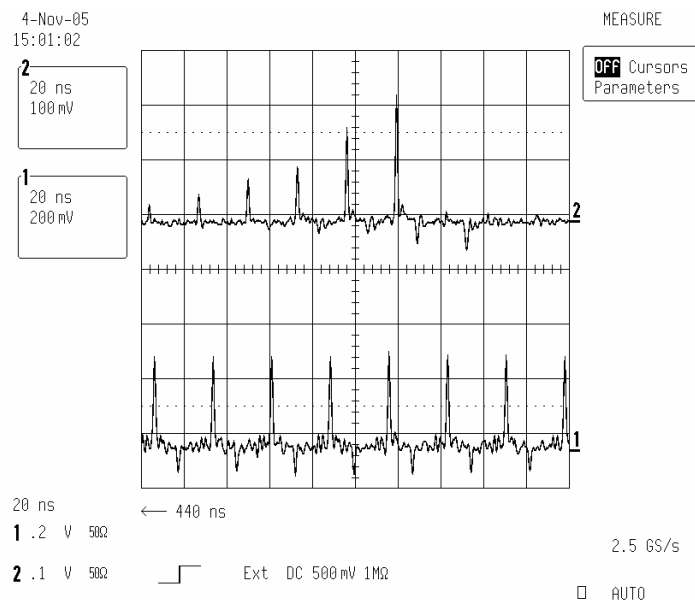
This function allows the user to inhibit or enable the high voltage signal sent to the electro-optic switch located inside the laser, via a TTL signal.

Applied voltage	Synchro signal
0 V	Inhibited
5 V	Enabled


III.3.6.3.3 Threshold detection

During the laser development performed in WP2, as well as during the initial tests, it was observed that the first pulse coming out of the laser had a higher energy than the subsequent pulses. This is caused by energy storage in the crystal during the time where the diodes are active. To maintain a constant energy level, we developed a specific control system.

We continuously monitor the pulse energy inside the regenerative amplifier. We trigger the high voltage electro-optic switch once the pulse energy reaches a factory set threshold, and not after a fixed time as was the case initially.



Monitoring of the pulse build-up in the regenerative amplifier (top), and of the oscillator pulse train (bottom).

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III.3.7 WP3.6: Risk management of the work package

Lasea create an internal WP3 group involving the 3 engineers working in this task. The goal is to organise and manage the different partners and supplier in order to get the right control system and vision system at the right time. Lasea has begun the Task 3.4 well before expected to be able to realise the reading test on WP1 samples. A lot of meeting and teleconferences have been conducted with KST and Amplitude for the communication with the new laser, and with SOLOS regarding the reading issues. New control system has to be checked with the new laser source, but we have had more than one month late due to mechanical delay of the WP2. Workpackage 3 was finished at the end of November, except the task 3.5 that goes on until February (optimisation).

III.3.8 Conclusions

Reading system and control system are finished and manufactured. Reading system have been checked thanks WP1 samples and WP3.2 samples. Control system has been checked thanks to YAG laser (WP3.4) and has been validated with the new laser coming from AMPLITUDE. Following the integration, some modifications have been made on the control system.

The WP3.5 task and iteration to optimise the control unit and the laser has been done allowing the fine-tuning of the control unit and defining the areas of improvements for the prototype engraving system (WP5)

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III.4 WP4 First validation with the Femto laser prototype

III.4.1 Work package flow chart

Seeing the late on the laser delivery, the task 4.4 began before the others ones. The WP4 meeting has taken place at Epone, under the management of Costet, on the 15th September 2005. The results of the SMEs (mainly Solos and TBS for pharmaceutical and Costet for Perfume industries) were shared and the tests procedures for the fields' tests (WP6) were fixed.

After the new laser delivery (October), Amplitude, Lasea and KSTs worked on the integration of the different subsystems in Lasea laboratory. This tasks (4.1 & 4.2) involved many resources of the three companies in order to begin the validation at the end of January.

CSL worked on the tests and microscopes analysis of the results (4.3). Pala led the galva head used in their laboratory during the WP1 to perform the new tests and allowing the comparisons. Results were shared and discussed with the two research centres.

This workpackage led to the main conclusions for the construction of the prototype (WP5) and allowed the optimization of optical systems by a better understanding of the process and of the main parameters.

Two deliverables have been sent to the Commission in the beginning of February:


Deliverable No	Title
4.2	WP4 Tests report - Preliminary engraving characteristics (25p)
4.3	Specifications of the field tests to be performed with the real objects (14p)

The main points of these reports are summarized in the following task descriptions.

The tests procedures and tests forms are described in the deliverable 4.2, based on the different requests of the SMEs and end-users.

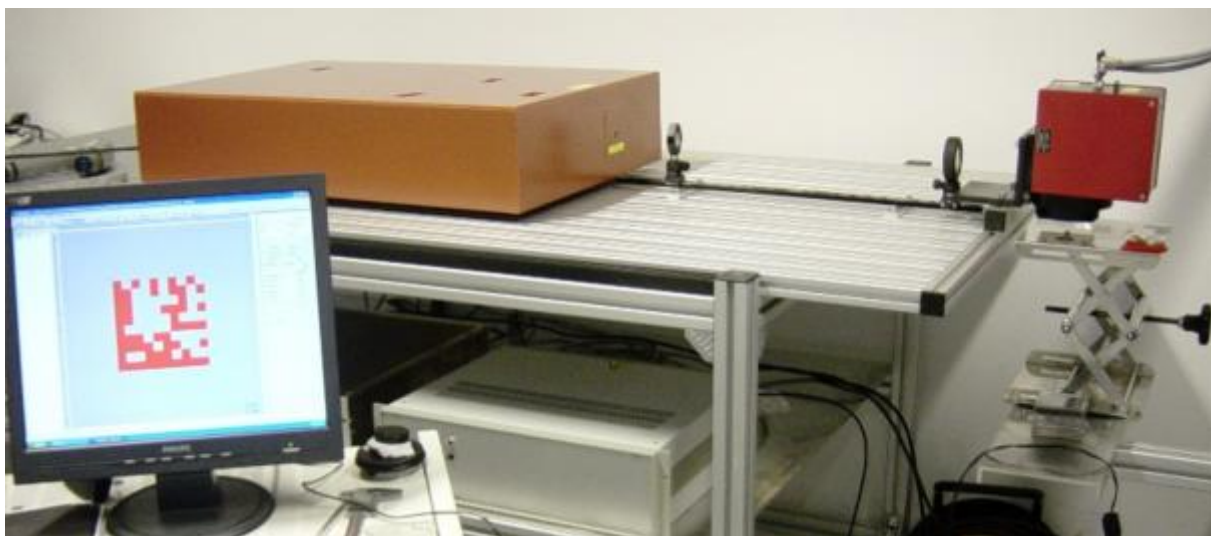
The results of the tests are summarized in the deliverable 4.3, based on the different tests and analysis of the RTDs. It is divided in 6 main parts.

» Chapter II:	Cells shape	p 5
» Chapter III:	Spot size	p 8
» Chapter IV:	Summary of the comparisons	p 13
» Chapter V:	Beam quality	p 14
» Chapter VI:	Reading tests on real samples	p 21
» Chapter VII:	Comparison of the speeds	p 24

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III.4.2 WP4.1: Integration of the laser source and control unit at laboratory scale

The control unit (developed in WP3) and the new Femto laser source (developed in WP2) are integrated at a laboratory scale in Lasea application lab. Strong relationship between KST, Amplitude and Lasea and between WP2.4 and 3.5 allowed a perfect integration of the sub-systems.



Laboratory configuration

III.4.3 WP4.2: Validation of overall process performance

The process performances have been validated on samples.


Main problems to solve before prototype manufacturing were:

Engraving:

- ü Quality is good with a short focal length but no refractive index with high focal length
 - ⇒ New optical system has to be developed to increase work distance (> 5mm) and field size (> 2 x 2mm)

Industrial version:

- ⇒ Automatic starting procedure has to be improved to reduce warm up time

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Reading:

- ⇒ High speed is not compatible with very small readable datamatrix (< 200µm)
- ⇒ Cost and size of reading device have to be improved

Lasea and CSL have worked mainly on increasing focal length and development of new optical systems. Solos and Lasea worked on the optimisation of reading systems.

Amplitude and KST worked on the problems of start procedure and industrial reliability.

III.4.4 WP4.3: First engraving experiments allowing a comparison with WP1

III.4.4.1 Objectives

The objective of this tests campaign is to compare different configurations in terms of:

- » spot sizes
- » shape of datamatrix cells,


which are 2 key parameters for the diffractive effect quality. These parameters have to be checked with the new fs laser, which has a repetition rate 100 times more than that of the laser used during the previous tests of WP1 (Deliverable 1.1, May 2005).

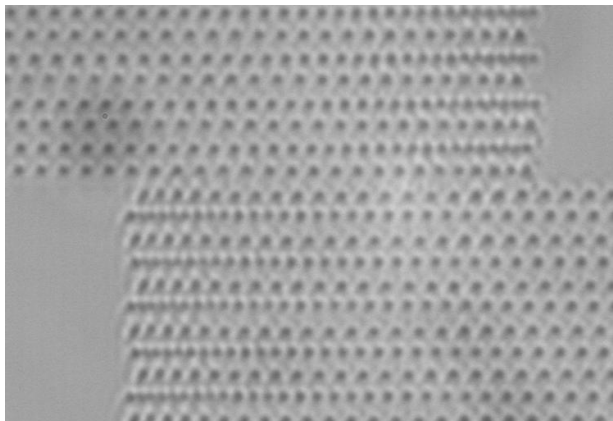
This laser has an output beam of 2.3mm, which is enlarged by a beam expander, and a fixed energy of 10µJ. The galvanometric head has an aperture of 14mm.

These tests have been performed in 6 configurations, using beam expanders of 4x and 12x, lenses of 17mm and 56mm of focal length, and galvanometric heads of 14mm and 30mm apertures.

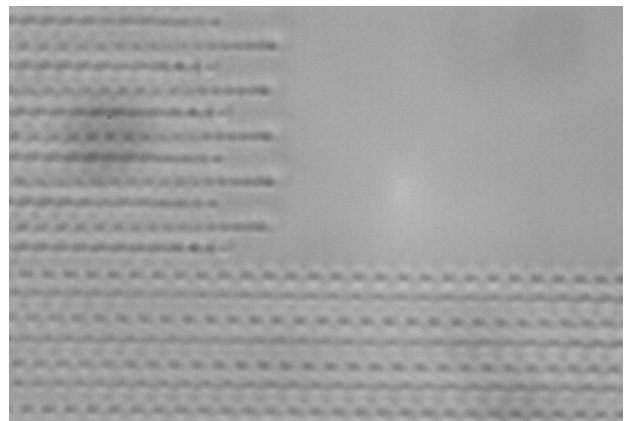
III.4.4.2 Cells Shape

In a datamatrix, the cells shape mainly depends on the delays between the beam displacement and the laser pulse. Sweeping parameters are well set when cells are squares and dots aligned. These parameters depending on the work field, they have to be determined for each lens. For 2x2mm datamatrix, the influence of a slight delay between mirrors positioning and the laser pulse is small, as it can be seen on figures below. This does not affect the reading of the code.

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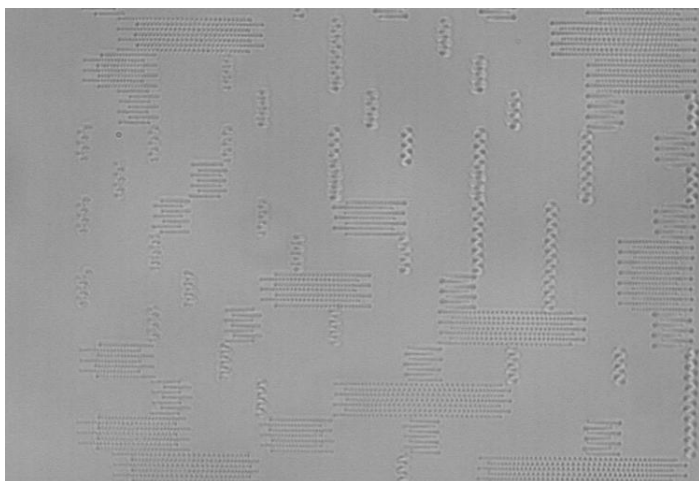


2x2mm - F=17mm/BEx12 G=50x

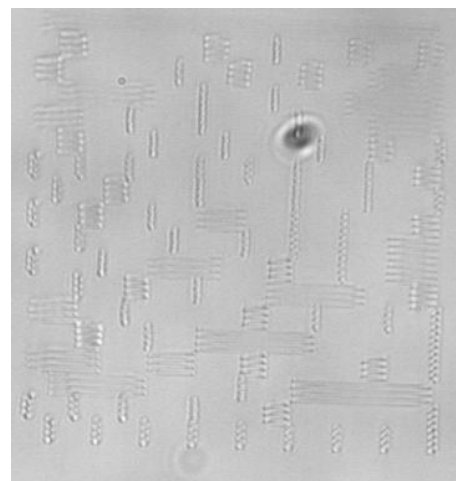


2x2m - F=17mm/BEx4 G=50x

However, for smaller datamatrix sizes, the shift between lines can become of the order of the cell size, which makes impossible the code reading.



0.5x0.5mm /F=17mm/BEx12 G=10x




0.5x0.5mm /F=17mm/BEx4 G=5x

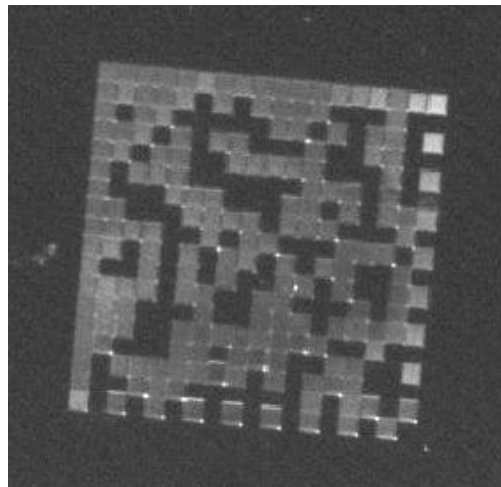
⇒ To be sure to obtain a less rectangular shape, it is possible to do a cross hatch, that is to say to make 2 sweeping, one horizontally, and the other vertically.

This process lets obtain more adapted shapes but dots superimposition cannot be precisely controlled.

Nevertheless, thanks to many microscope measures, the right concordance parameters between the software, the galvanometric head, and the laser have been found.

To obtain perfectly squared cells, another sweeping method has been successfully tested. This method consists on creating an array of datamatrix of only one dot by cell, these datamatrix being shifted by the appropriate distances in the x and y directions. However, this method is a lot slower, as we will see further.

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1x1mm |F=17mm|BEx8|Reading Camera

III.4.4.3 Spot Size

Spots or lines sizes are a very important parameter for diffraction quality.

The different configurations feature different spot sizes as it is explained in this section.

III.4.4.3.1 Configuration 1: 17mm Lens – BE x12 – Laser Head 14mm

In this configuration, D/F ratio is of 1.6. Measured spot size is of 1.8 to 2µm.

During WP1 tests, a smaller size had been obtained with a D/F ratio of only 0.82. We will see further why we do not obtain smaller dots here, theoretically of 1µm.


III.4.4.3.2 Configuration 2 : 17mm Lens – BE x4 – Laser Head 14mm

D/F ratio is here 0.54. Measured spot size is 2.5µm. For a 0.54 D/F ratio, spot size should have been of 2.7µm. Here, the measured size is 2.5µm, which concurs with theory.

However, WP1 results indicate for this ratio a lot smaller spot size, of the order of 1 to 1.5µm.

III.4.4.3.3 Configuration 3 : 56mm Lens – BE x12 – Laser Head 14mm

D/F ratio is 0.49. Measured spot size is about 4 to 5µm. The D/F ratio being close to the one of configuration 2, spot sizes should have been of the same order, as it depends only on the wavelength and this ratio. It is here superior. The explanation of this phenomenon comes from the galvanometric head aperture. Indeed, the head has an aperture of 14mm, which cuts a large part of the beam when it is enlarged 12 times. The beam has then a 27.6mm diameter.

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Although the size of the focal spot is not the same than for a 14mm beam, it is still larger because of a beam quality loss when it is cut by a diaphragm.

The same phenomenon occurs in configuration 1, which explains that we do not obtain 1µm spots.

III.4.4.3.4 Configuration 4: 56mm Lens – BE x4 – Laser Head 14mm

In this configuration, figures are very blurred. Macroscopically, we only observe a colour change but no diffractive effect. D/F ratio is of 0.16. Spot size is of 6µm.

Theoretically, expected spot size for this ratio is of 9µm. Here we have a spot size slightly smaller, which can be explained by a too low energy density on the edges of the beam to create an index or colour change.

Results from WP1 tests indicate similar spot size, around 5.5µm.

III.4.4.3.5 Configuration 5: 56mm Lens – BE x12 – Laser Head 30mm

With the use of a larger head, figures are still blurred, despite the fact that the power is higher than with a 14mm head, and that the beam quality is not reduced due to the cutting of the beam. Spot size is around 4 µm. This blurred effect can easily be explained by the mirror qualities of this 30mm head, as we will see further. However, at 1kHz, during WP3, better results had been obtained with the same head and the same D/F ratio.


III.4.4.3.6 Configuration 5: 56mm Lens – BE x4 – Laser Head 30mm

Once again, in this configuration, no diffractive effect is obtained. Spot size is of 6µm, but a large area around dots is affected. The size of this area can be estimated to 10µm

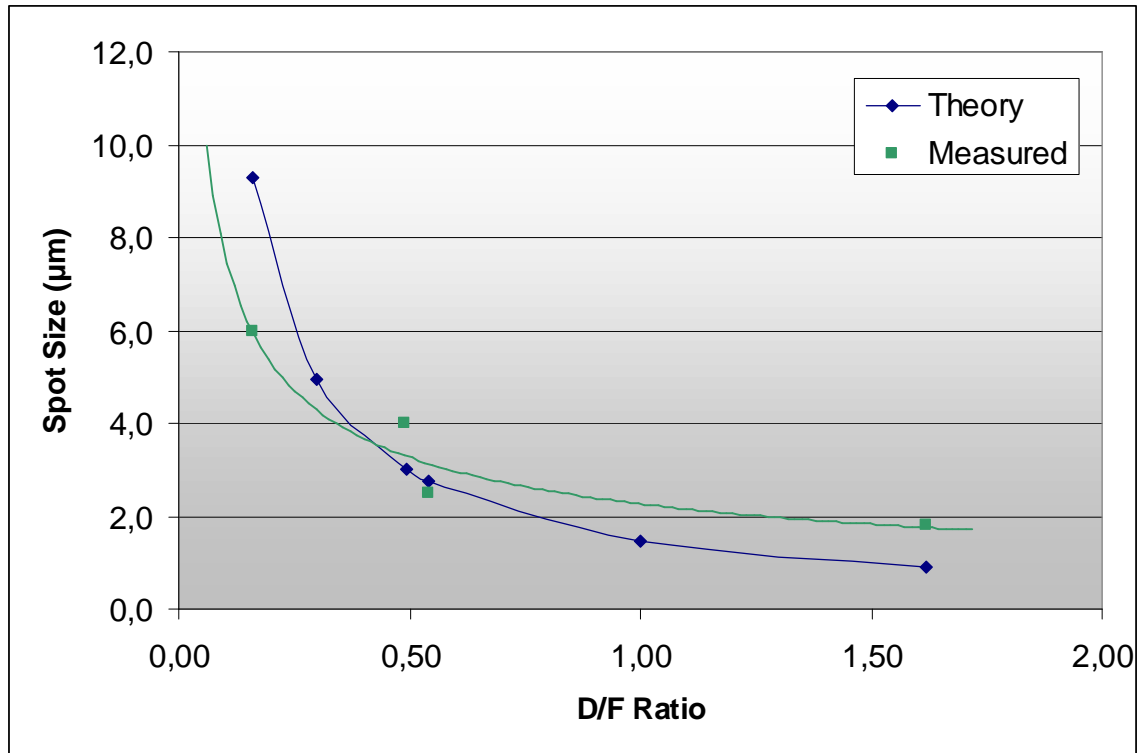
III.4.4.3.7 Summary of the comparisons

Here is a summary of the measured spot sizes in the four configurations described above:

	Aperture (mm)	F (mm)	Beam Exp.	D/F ratio	Theoretical Spot size (µm)	Measured Spot size (µm)
Configuration 1	14	17	12	1,62	1	1,8
Configuration 2	14	17	4	0,54	2,7	2,5
Configuration 3	14	56	12	0,49	3,0	4,0
Configuration 4	14	56	4	0,16	9,0	6,0
Configuration 5	30	56	12	0,49	3,0	4,0
Configuration 6	30	56	4	0,16	9,0	6,0

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These spot sizes can be plotted on a graph in function of the D/F ratio:




Spot sizes in function of D/F Ratio

The measured spot sizes are very close to the theoretical ones. It appears that the diffractive effect is lost when the D/F ratio is less than 0,5, corresponding to a spot size of 3,2µm.

In spite of the larger aperture with the 30mm head, the results have been unchanged. The spot sizes are the same and no diffractive effect can be observed with the 56mm objective.

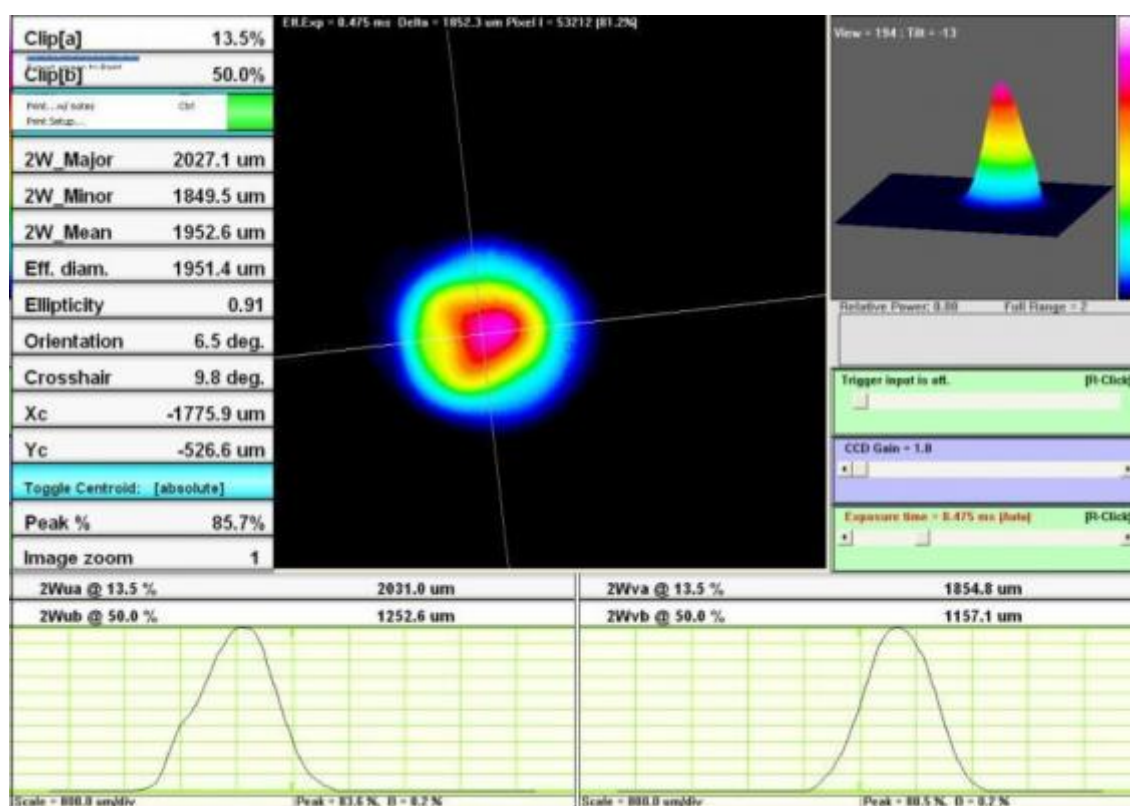
We can conclude that at this higher repetition rate, a phenomenon occurs, which makes impossible to obtain the same results than we obtained in WP3.

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III.4.4.4 Beam quality

Spot sizes, and therefore the diffraction quality, depends on the D/F ratio, but also on the beam quality. Indeed the noise in a beam profile results in an enlarged profile of the spot at the focus point. That is why the beam profile has been measured in several configurations.


The following figure shows the profile of the laser output beam. Although it is not perfectly Gaussian, its quality is still very good.

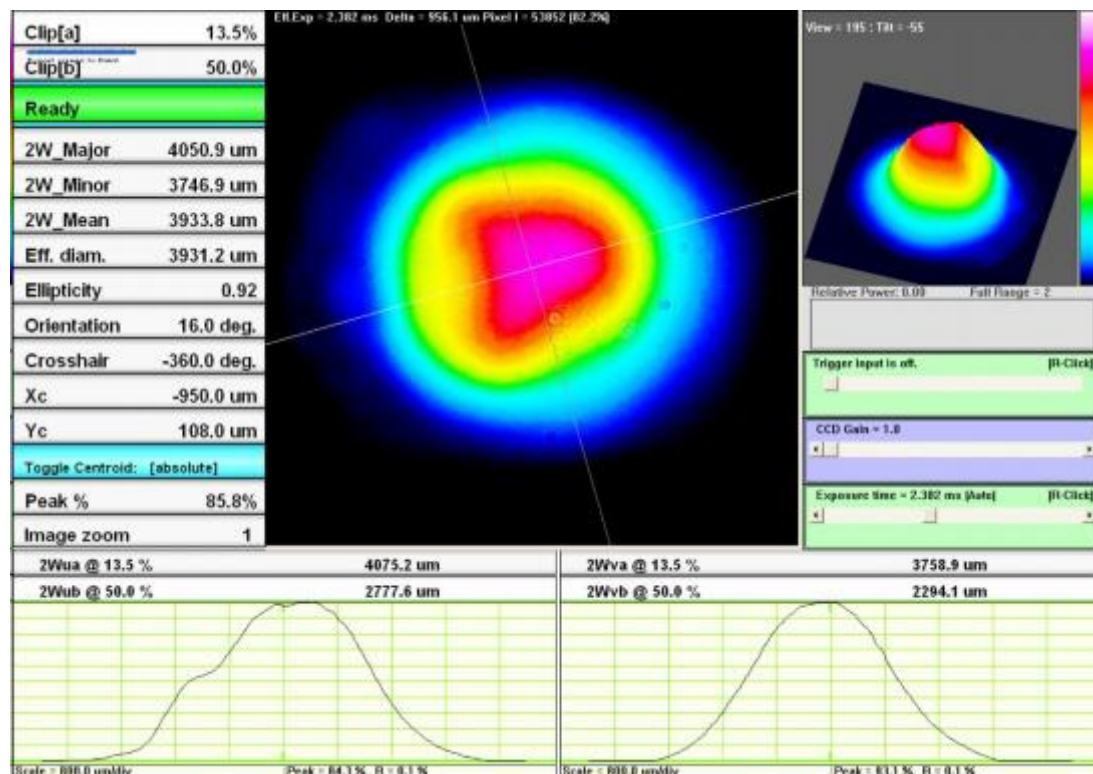


Output beam

The measured beam size is not the exact dimension because of a slight focusing of the attenuator used.

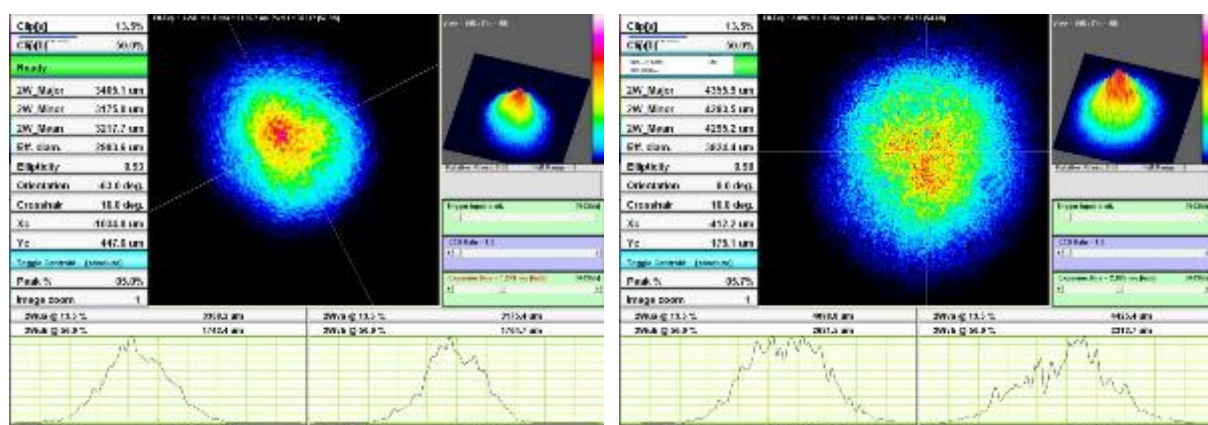
The profile quality at the output of the beam expander is not reduced.

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Output of the beam expander x2 (BE x2)

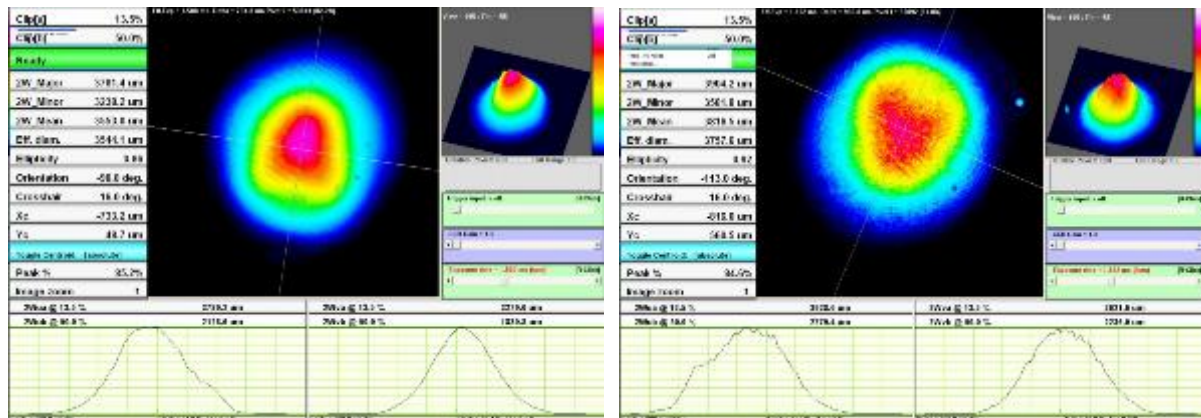
Two galvanometric heads have been used. The following profile is the one measured after the 30mm head used during the WP1 tests. The quality is very low because of damaged mirrors, and it is even more reduced after the focusing lens.



Output of the 30mm head with BE x2 without objective (left) and with 56mm objective (right)

The second head used is a smaller one as it only has an aperture of 14mm. The beam quality is not reduced by mirrors, but the focusing lens induces a small noise on the profile.

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Output of the 14mm head with a BE x2 without objective (left) and with 56mm objective (right)


III.4.4.5 Reading tests on real samples

New samples have been submitted to tests with configuration 1. 18x18 cells Datamatrix of different sizes have been engraved on small vials or bottles.



small selection of the sample production

For good quality glasses, reading tests are successful for datamatrix sizes of more than 300µmx300µm.

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Marking times are:

- » 2mmx2mm: 4.5s
- » 1mmx1mm: 1.7s
- » 500µmx500µm: 0.7s
- » 200µmx200µm: 0.24s
- » 100µmx100µm: 0.13s

As expected, the times are almost 100 times shorter than during WP1.

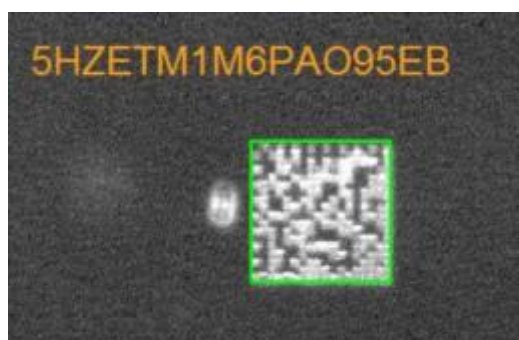


Reading of a 500µmx500µm datamatrix


To obtain readable codes for sizes down to 100x100µm, the second sweeping method has to be used, but it is a lot slower.

Marking times are:

- » 2mmx2mm: 239s
- » 1mmx1mm: 40s
- » 500µmx500µm: 7s
- » 200µmx200µm: 1.5s
- » 100µmx100µm: 0.7s

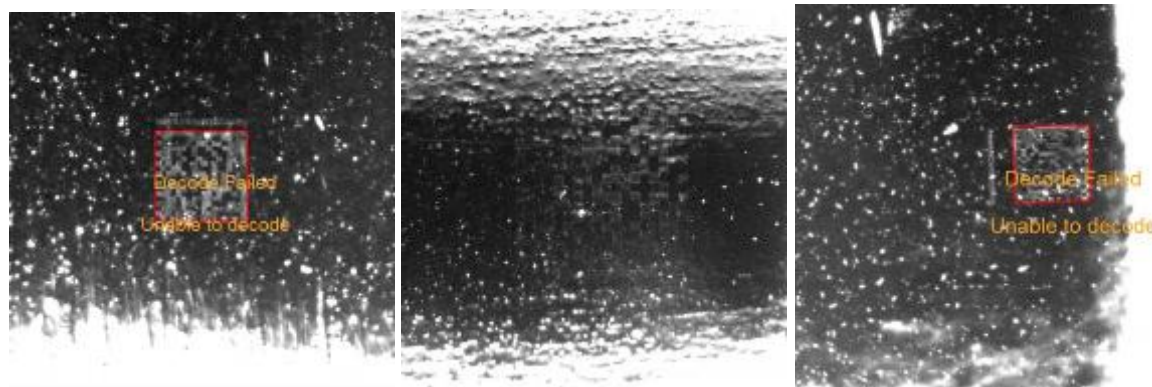


Reading of a 200µmx200µm datamatrix with the second sweeping method

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These marking times are longer, but they are still twice as short as during WP1.

Now for low quality glasses, readings may become impossible because of bubbles inside the glass or a low surface quality.




Failed readings due to low quality glasses

III.4.4.6 Comparison of the speeds

Comparison of process time during WP1 (1kHz) – WP1 (10kHz) – WP3 (100kHz (estimation thanks YAG laser) and WP4 (100kHz):

	Time (s)	DM 1mm	DM 200µm	DM 100µm	DM 60µm
WP1	1kHz (PALA)	225,00	22,20	10,40	
	10kHz (PALA)	33,70	4,30	2,30	
WP3	100kHz (Lasea)	1,64	0,27	0,08	0,07
WP4	100kHz (Lasea)	1,42	0,24	0,13	0,09
	Relative time				
	1kHz (PALA)	97,83	9,65	4,52	0,00
	10kHz (PALA)	14,65	1,87	1,00	0,00
	100kHz (Lasea)	0,71	0,12	0,03	0,03

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III.4.5 WP4.4: Specifications of the field test to be performed with real objects

This task has begun in September 2005. SMEs have seen potential end-users to get specifications of tests and have prepared samples to be tested.

Solos has had meeting with pharmaceutical industries and wine industry, TBS has met luxury goods industries, Costet prepared its own samples, and visit the end-user LVMH, KST and Lasea have had meeting with the two end-users : Pilkington (Glass) and GlaxoSmithKline (Pharmaceutical).

Amplitude has worked with LASEA and the SMEs to define the tests which are to be performed using the new laser.

A meeting was held in Epone on 15/09/2005 to summarize the different tests to make in WP6 in order to validate the new technology.


Costet has prepared with TBS and SOLOS the future tests of the system:

III.4.5.1 TEST #1 and TEST #2 Tests for the counterfeiting applications.

- a Evaluation of the speed of engraving with different depth expressed in second .
- a The evaluation of the quality of the reading of the data matrix code .The evaluation will be made with the results given by the camera + soft ware
- a The evaluation will be expressed in % .
- a The results of the speed of engraving + % of the reading will be written in the chart bellow for each samples .

The main objectives of these tests are:

1. To validate that the new laser engraving is feasible on different bottles shapes in flint glass
 - a. Cylindrical b. Flat c. Oval d. conical
2. To validate that the new laser engraving is feasible on coloured glass
 - a. Cobalt blue b. Green c. Yellow / Brown
3. To validate that the laser engraving is feasible on glass with surface treatment
 - a. Acid etched b. Painted translucent paint shiny clear c. id. satin clear
 - d. id. shiny dark e. id. satin dark

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The motifs will be made of 2 shapes

1. Disk / a cylindrical motif in a shape of a full disk
2. Rings / few rings with different diameters

The main objectives of these tests are:

1. To validate that the engraving of diffractive effect motifs is feasible on different bottles shapes in flint glass
 - a. Cylindrical b. Flat c. Oval d. Conical
2. To validate that the engraving of diffractive effect motifs is feasible on coloured glass
 - a. Cobalt blue b. Green c. Yellow / Brown
3. To validate that the engraving of diffractive effect motifs is feasible on glass with surface treatment
 - a. Acid etched b. Painted translucent paint shiny clear c. id. satin clear
 - d. id. shiny dark e. id. satin dark
4. To validate that the engraving of diffractive effect motifs is feasible on flint glass from different glass makers with variable sodo calcique glass formula
 - a. a. SGD b. Pochet c. Luigi Bormioli d. Rocco Bormioli
 - e. NVM f. Heinz g. Brosse h. Crisbisbal i. Stolzle


III.4.5.3 TEST #4 – Pharmaceutical sector

Definition

- § To engrave a data matrix code that contains lot number, date of production, date of expiration
- § Evaluation of the speed of engraving **vs** capacity of datamatrix (number of alpha-numeric characters encoded)
- § Evaluation of datamatrix size vs capacity in respect of reading quality.
- § Speed will be measured in sec or msec.
- § Reading quality expressed according to grade based on “direct part marking standard”

Objectives

- § Size of datamatrix : 2x2 mm ; 1x1 mm ; 0,5x0,5 mm ; 0,2 x 0,2 mm ; 0,1 x 0,1 mm
- § Different code capacity : 10x10 ; 12x12 ; 14x14; 16x16; 18x18; 20x20; 22x22; 24x24
- § Marking speed must be lower to 100 ms to fit requirements of filling machine used in the pharmaceutical sector

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- § Different glass containers : vials with different diameters, syringe with different diameters

Conclusions

- § What's the maximum capacity of the datamatrix in function of datamatrix size with the respect of a max cycle time of 100ms ?
- § What's the impact of vials diameter in function of datamatrix size? What's the limitation due to the radius of curvature ?
- § What's the reading performance in function of datamatrix capacity for a specified datamatrix size ?


III.4.5.4 TEST #5 – Automotive glass sector

Definition

- § To engrave a data matrix code that contains lot number, date of production, glass type
- § To engrave logo (refractive motifs) to create “watermark”
- § To engrave text items
- § Evaluation of the speed of engraving. Speed will be measured in sec.
- § Reading quality of datamatrix expressed according to grade (based on “direct part marking standard”)
- § Evaluation of datamatrix size **vs.** capacity in respect of reading quality.
- § Text & Logo: The evaluation will be based on Aesthetic and Visual quality. The control is made by human eyes

Objectives

- § Different automotive glass : coated glass or coated interlayer (for laminated glass), laminated glass, colored glass (mainly privacy ones), toughened glass, glass with black enamel
- § Size of datamatrix : 5x5 mm ; 2x2 mm ; 1x1mm; 0,5x0,5 mm ; 0,2 x 0,2 mm ; 0,1 x 0,1 mm
- § Different code capacity : 10x10 ; 12x12 ; 14x14; 16x16; 18x18; 20x20; 22x22; 24x24
- § Logo : Automotive Company logo (Renault...) or glass manufacturer (Pilkington...)
- § Text : European N°, date of production, glass type (similar to the current identification of automotive glass)
- § Marking speed must be lower than 1sec.

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Conclusion

- § What's the impact of glass structure on the engraving results, reading performances and aesthetic aspect?
- § What's the maximum capacity of the datamatrix in function of datamatrix size with the respect of a max cycle time of 1sec ?
- § What's the reading performance in function of datamatrix capacity for a specified datamatrix size?

III.4.6 WP4.5: Risk management of the work package


WP4 was carried out under the responsibility of Costet SAS. One meeting held in Epone in September. Thanks to detailed exchanges between Amplitude, LASEA and KST under workpackages 2.6, as well as workpackage 3.5, the laser integration proceeded without any major adjustments necessary. Workpackage 4 was finished at the end of February, except the task 4.4 that goes on until April (new optical system development & further tests).

III.4.7 Conclusions

Task 4.4 has allowed the redaction of the forms and test procedures for WP6

Thanks to the laboratory set-up, the following conclusions on the process have been found:

- ü The tests have let us observe the shape of datamatrix cells and made it possible to adjust sweeping parameters to reach an optimum geometry of the cells.
- ü The new spot size measures have let us validate the tests at a 100kHz repetition rate. Some of the values obtained in WP1 are slightly different with these new measures, but these new ones are coherent with theory. However, the high diffractive effect obtained during WP3 with a 56mm focal length has not been obtained in this new configuration (100 kHz). The understanding of these differences has been achieved before continuing to produce samples for end-users companies (KST, COSTET, TBS, SOLOS).
- ü The best results are obtained with high D/F ratio. The diffractive effect seems to be lost when this ratio is less than 0.5.
- ü A study of the beam quality has been made, which led to a better understanding of the requirements on the laser beam quality.
- ü Marking times are now reduced by almost a factor 100 compared to WP1.
- ü Readings are successful for datamatrix sizes down to 100µm.

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III.5 WP5 Development of a prototype laser processing

III.5.1 Work package flow chart

Following the task 1.1, different possibilities have been evaluated by KST based on the functional requirements of COSTET (see deliverable 1.3). Multi- axis robot and XYZ tables have been evaluated. Meeting with Lasea, KST and COSTET has permit to summarize the different possibilities and take a decision for the future prototype.

TBS, SOLOS and Costet prepared the reports and specifications of the Market. Visits to the end-users (Pilkington, Glaxo-Smith-Kline) have been organised and specifications have been studied (WP3 & 4).

Thanks to the results of WP4 (integration of the subsystems at laboratory scale), the main issues and limitations have been demonstrated.

The WP5 is the longest workpackage. It began in 2004 and finished at the end of the project It has involved a lot of competencies:

- » KST (mechanics, integration, control/vcommand)
- » Amplitude (laser, safety issue, communications)
- » Lasea (Optical system, reading devices, engraving software)
- » Costet (specifications for fragrance market, tests & development for a fragrance production line)
- » SOLOS & TBS for the specifications of the pharmaceutical & luxury markets

The approach consists of a '2 steps' logic:


1. Demonstration unit

The development of a full demonstration unit (design, engineering, execution and process validation tests on this unit) must confirm all the expected performance of the NAGINELS core (femto laser, specific vision equipment, control/command racks, safety logic and dedicated software approach).

This work was executed by KST and LASEA partners.

2. NAGINELS core in industrial environment (fragrance production line)

The feasibility study of the implementation of this NAGINELS core on a fragrance production line confirms the industrial viability of this concept. This study made with different machine builders take care of line integration aspects (takt time, marking process optimization, process communication interface and impact of industrial environment –vibration...- on the NAGINELS core).

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Two meetings have been organised: the 19th January 2006 for the presentation of the design study and the 12th July 2006 for the presentation of the prototype.

All the elements of the development of the prototype and the study on fragrance production line were summarised in the deliverable 5.1 (43p) sent to the Commission in December 2006. The document is divided in 4 main parts. The three first parts will detail the needs for the technology, the design and the final engineering. The last one details the study made by Costet and KST on the integration on fragrance production line:

» Chapter II: Requirement	p 7
» Chapter III: Conceptual phase	p 10
» Chapter IV: Detailed engineering	p 20
» Chapter VII: Application to fragrance industry	p 32

The main points of the 3 main chapters are summarized in the following task descriptions.

III.5.2 REQUIREMENTS

III.5.2.1 Prototype – demonstration unit concept


The prototype is not supposed to be an industrial unit but it must be realistic in terms of working rate, accuracy, reliability and safety concept. The prototype must cover the engraving (marking) process (laser) and the marking verification (vision system). This verification gives an immediate feedback on the readability and quality of the engraved code.

III.5.2.2 Performance

The pharmaceutical and fragrance applications are similar, but the following differences have been identified:

	Pharmacy	Fragrance
Bottles size	Very small (vials)	Bigger
Handling – Glass Fragility	Solid	Sensitive
Handling – Glass Thickness	Very thin	Thicker
Expected process rate (takt time)	Up to 5 pces/s	~ 1 pce/s
Positioning - accuracy	0,05 mm	same

Performance table

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The prototype must have the flexibility to comply with these specific requirements. It must be accurate enough to engrave a code on the small vials, but also able to treat bigger bottles.

III.5.2.3 Prototype targets

III.5.2.3.1 Configuration

The prototype must work in a demonstration - stand alone configuration. But, on the control process layer, the selected technology must authorise evolution to a production integrated approach. So, part time of the engraving process can be simulated on this unit.

III.5.2.3.2 Process targets


The process targets required are:

- Safe working conditions (Based on a risks evaluation study).
- Engraving and moving in 200 msec (Depending on Laser performance and motion control capabilities)
- Control of the engraving (Depending on Vision system performance and motion control capabilities).
- Producing up to 5 pces/sec for small pieces (*Pharmacy vials...*).
- Producing up to 1 pce/sec for bigger pieces (*Fragrance bottles...*).

III.5.2.3.3 Control layer targets

The prototype will include many subsystems which will need to be controlled and interfaced:

- Control of laser and galva head.
- Control of the vision system.
- Control of the moving solution.
- General hardware control, including safety interlocks.
- Human interface (HMI) based on a PC technology.
- Local database management and interface towards possible higher level information system (MES level).
- Machine to machine concept (easily controllable from an existing plant network: Ethernet-TCP/IP).

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III.5.2.4 Pieces handling

The handling technique must also be soft enough in order not to damage the fragile perfume bottles (no bulk conveying where bottles touch each other, for example). The handling technique must authorise takt time performance without heavy human action.

In a real industrial line, the loading and unloading operations would be very different for a pharmaceutical or fragrance application. In the first case, the required flow is very high (several parts per second) but bottles can touch each other. Bulk conveying is the most common technology. In the case of perfume industry, such a technology is ruled out because the bottles are often fragile, painted or coated, so that they should never suffer any shock or friction.

These considerations are not really relevant for the prototype: in both cases, there exist proven industrial solutions and our goal is not to design a real production line but to demonstrate the feasibility and performance of the process itself

Note: the focus of this prototype is the NAGINELS core not the handling: the prototype must only reproduce handling conditions given by industrial machine builder.

III.5.3 WP5.1 Design of the prototype engraving system

III.5.3.1 Design


III.5.3.1.1 Mechanical aspects

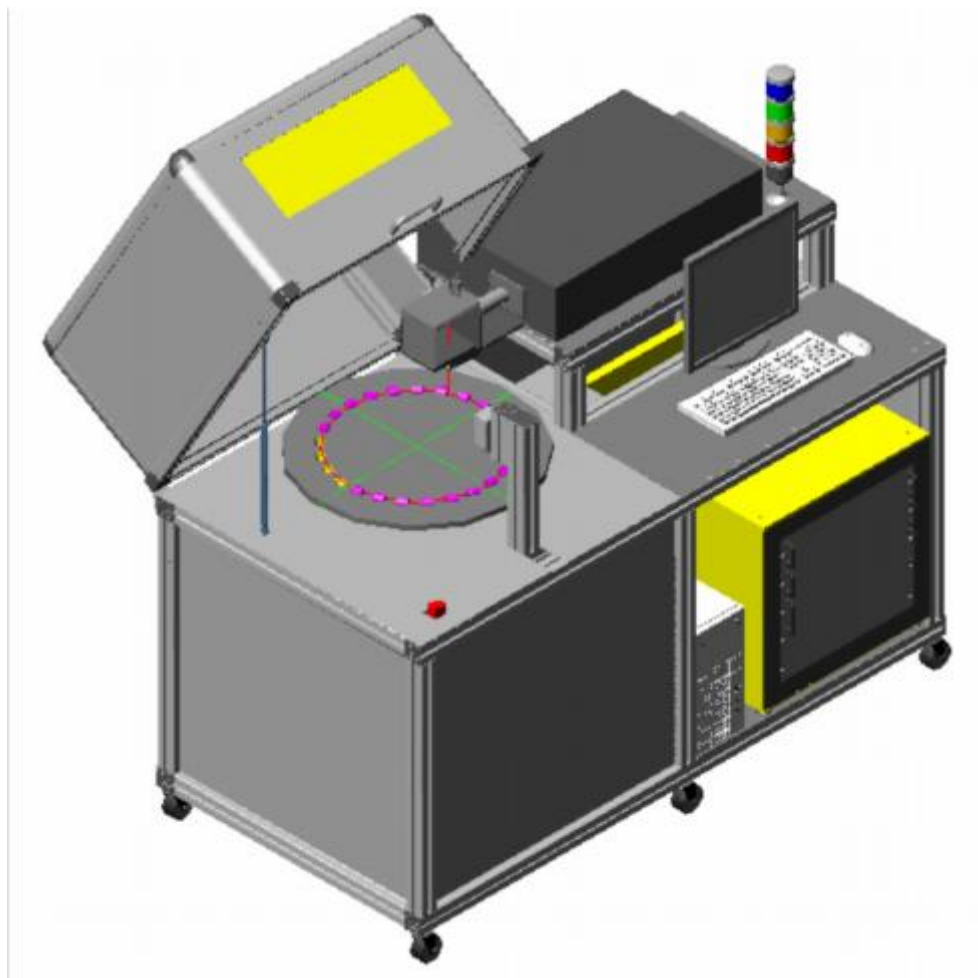
To reach the targets, equipment based on an 'indexed rotating plate' concept is selected.

The prototype machine allows the engraving and the control of one or several codes (datamatrix, OCR, ...) on pieces placed on a rotating plate.

The base plate of the indexing table can be equipped with different kinds of interface trays, adapted to the different type of bottles to be treated. This gives the full **flexibility** of shape (the trays will be designed and machined according to the product to be treated).

It will also be possible, in this way, to have a different number of positions according to the application.

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Equipment general design (first layout)

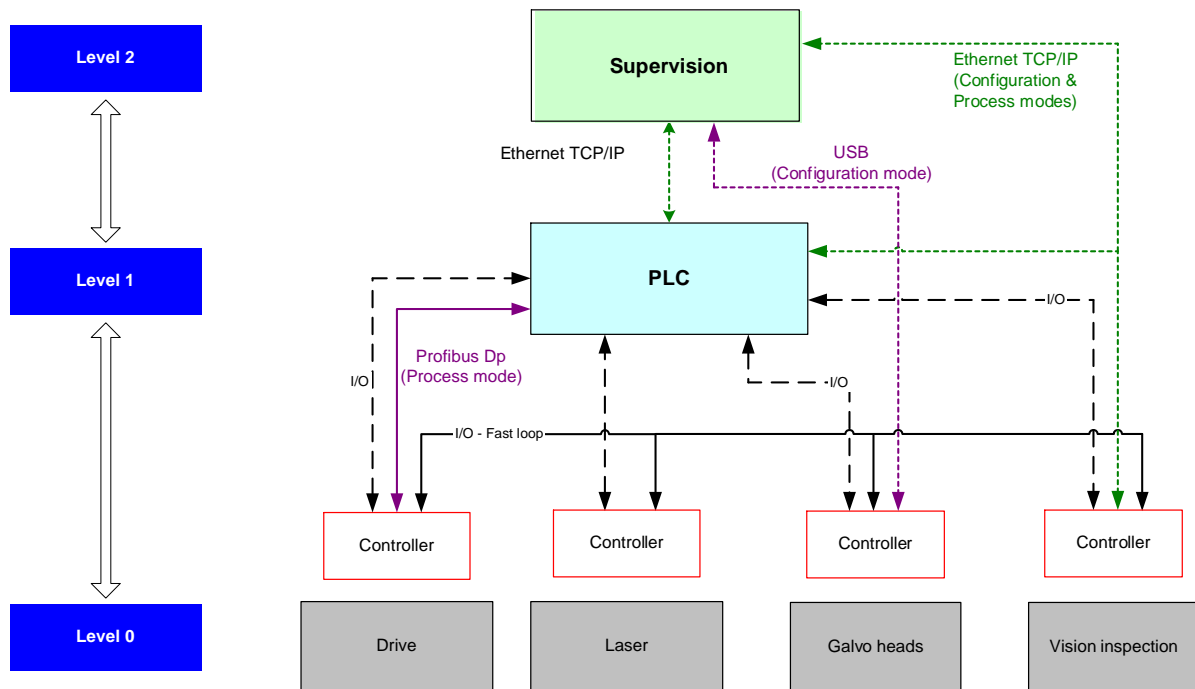
A vertical (manual positioning) adjustment of the indexing plate (and associated motion control) authorise a correct vertical positioning of the laser in order to be adaptable to different product shapes and dimensions.

III.5.3.1.2 Control process architecture

The control process architecture of the equipment is based on a 3 levels model:

- Level 2: Human Machine Interface – Supervision package on PC.
- Level 1: PLC for control/command and general process cycle synchronisation
- Level 0:
 - Fast cycle controller: drive motion control: I/O fast loop.
 - Laser controller.
 - Galva head controller.
 - Vision controller.

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Control equipment – General architecture


III.5.3.2 Safety Study

III.5.3.2.1 Approach

The most critical safety issue is the optical risk caused by the laser radiation (Class IV laser). The general principle is that the engraving post must be enclosed in an optically hermetic shell, making the prototype a Class I device (like a CD-reader...). The difficulty comes from the loading and unloading operations.

Seen the expected working rate, it is impossible to design the prototype neither with manual nor with automatic interlocked doors. These would indeed need to open and close 5 times per seconds for the highest rates.

So, the selected solution is to design the indexing table so that the operator is always optically isolated from the laser beam. In other words, the "automatic doors" are parts of the rotating table itself.

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III.5.3.2.2 Risks Evaluation

Electrical risks

The following risks are:

- Presence of 230VAC
- Presence of 400VAC

Adopted solution:

- Ø Mains (power on) light information
- Ø Disconnecting switch

Mechanical risk

The following risk is:

- Moving parts (plate and vertical positioning)

Adopted solution:

- Ø Housing of the movable part.
- Ø Housing switch and associated emergency controller logic.
- Ø Working information trough beacon.


Optical risk

The following risk is:

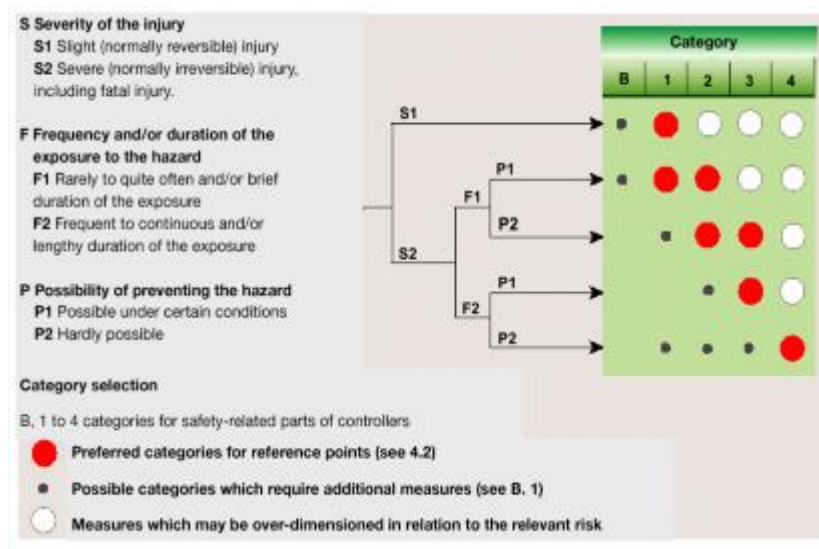
- Laser class IV technology.

Adopted solution:

- Ø Housing with materials in accordance with laser use. This solution grants that the operator is always optically isolated from the laser beam.
- Ø Laser warning information trough beacon.

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III.5.3.2.3 Safety device selection



Safety category selection

The safety device selection follows S2-F1-P1

The safety category is then 1.

III.5.3.2.4 High priority safety control


The following hardware points need an emergency validation through a dedicated safety controller:

- Emergency stop push button on machine.
- Emergency stop (external contact).
- Housing interlock (switch).
- Laser validation (keyed laser safety control).

III.5.3.2.5 Process alarm

The followings software points need only a supervision (PC human machine interface) validation:

- Motor Trip or not ready.
- Laser fault / High temperature.
- Laser fault / Current limit.
- Laser fault / External.
- Laser cooling unit fault.
- PC-PLC watchdog.
- Lost of communication between PLC and Drive.

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III.5.3.2.6 Process warning

The followings warnings are only showed for user's information:

- Housing interlock By-pass.
- Laser warning / Oscillator stable.
- Housing not closed.
- Position 0 not found.
- Laser warning / Laser ON.
- Vision warning
- Laser warning / Amplificator trouble.

III.5.3.3 Engraving / vision inspection logic

III.5.3.3.1 Positioning definition

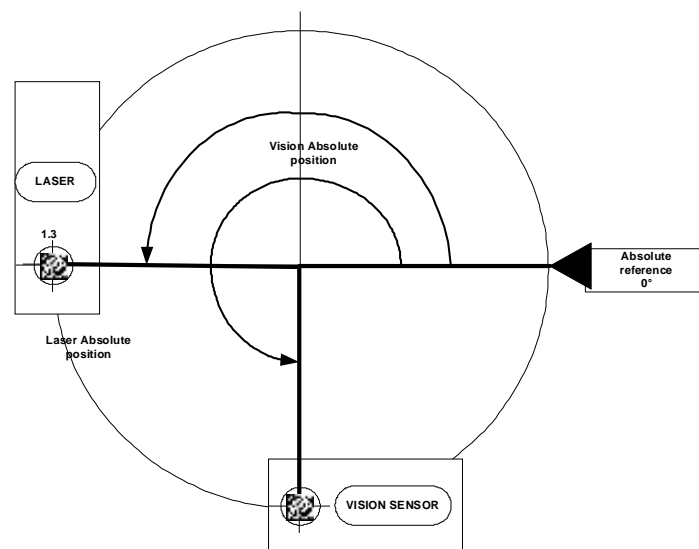
All the angles, on a plate, are measured counterclockwise from the zero position.

Laser absolute position [°]

This is the value of the angle between zero position and the laser engraving position.

Vision absolute position [°]


This is the value of the angle between zero position and the vision control point.



Angle reference (0 absolute – laser – vision)

Recommendations:

- ⇒ The angle between vision sensor and laser has to be at least equal to the angle between two samples on the plate or a multiple of this angle. So that, a sample can be engraved at the same time another one is being verified.

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Example: A plate is set-up to welcome 8 samples on it. All samples are 45° apart from each other. The different combination to set-up the laser and vision sensor are:

- An angle of 45 ° or
- An angle of 90° (that means that the checking will start after two engraving). But with this configuration it is allowed to run with 4 samples setup at 90 ° apart from each other.

III.5.3.3.2 Engraving logic

Normal mode - Single engraving

One datamatrix (for example) is engraved on one piece. The number of pieces determines the angle value between two engravings on a turn. (Angle value = $360^\circ/\text{number of pieces}$)

Parameters to set:

[Number of pieces] = 1

[Number of engraving] = 1

Normal mode - Single datamatrix on several pieces

One datamatrix is engraved on each pieces of the plate (the plate makes one turn).

Parameters to set:

[Number of pieces] = X

[Number of engraving] = 1

Normal mode - Several datamatrix on several pieces

Several datamatrix are engraved on the same piece (the plate make several turns according the parameters)

Parameters to set:


[Number of pieces] = X

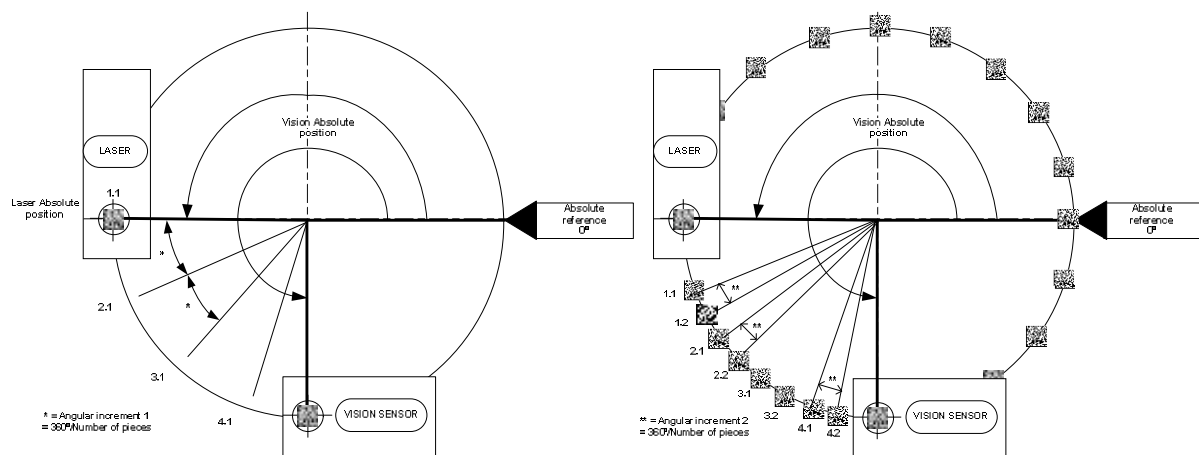
[Number of engraving] = Y

Smart Move option.

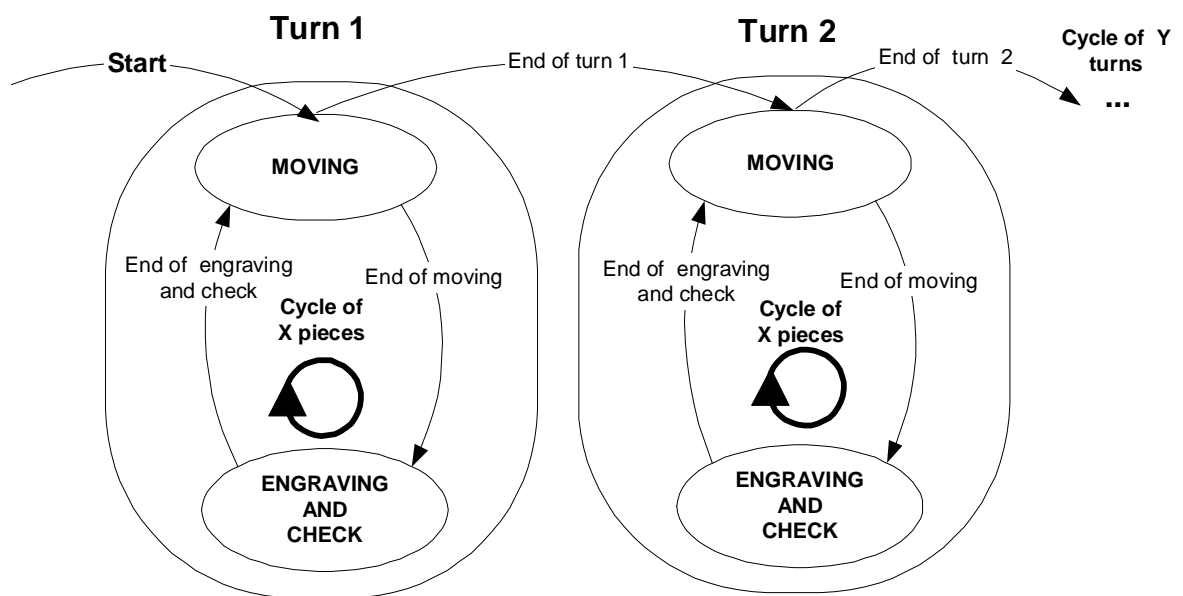
To avoid annoying vibration, another movement setup has been created. When enabled, movement will be the following:

The main difference between the normal mode concerns the way the second incremented is executed. Instead of shifting the rotating plate when the turn is completed, the offset is done after every engraving. So when several engraving on the same piece are required, all the datamatrix are engraved in a row. The cycle will be executed in one turn only whatever the number of pieces and the number of engraving asked.


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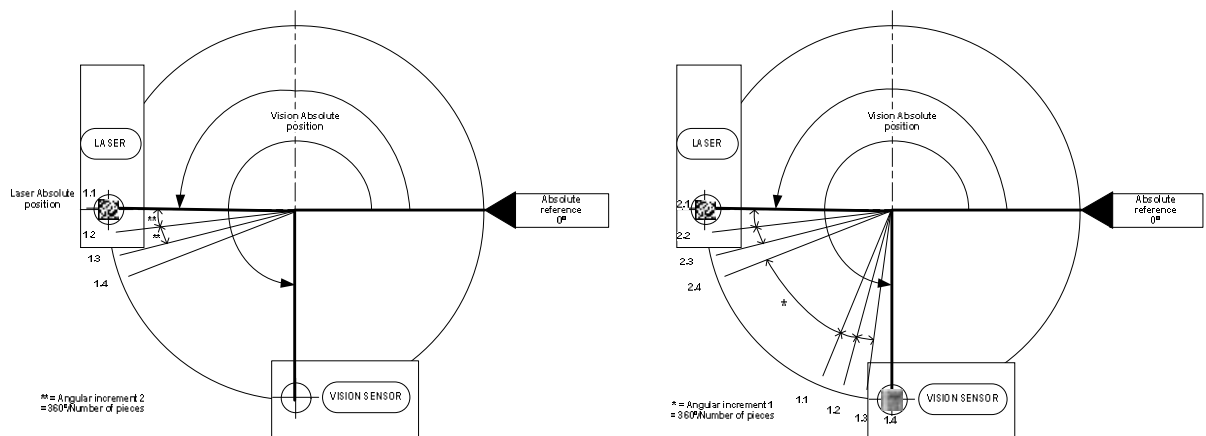


Normal mode – multi engraving



Normal mode – multi engraving – process cycle logic

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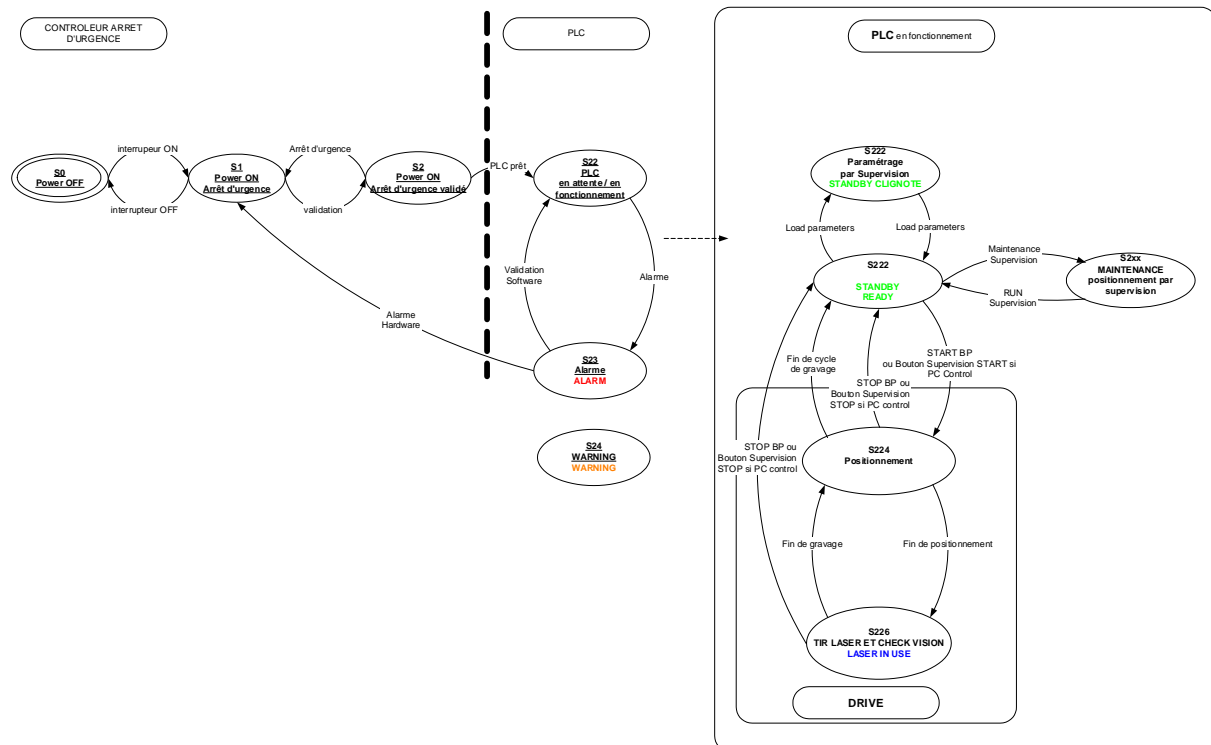


Smart move option – multi engraving


III.5.3.3.3 Valid states/transitions diagram

The process logic implemented on the PLC follows a valid states/ transitions diagram methodology.

The PLC code development follows this diagram (reference to steps and transitions)



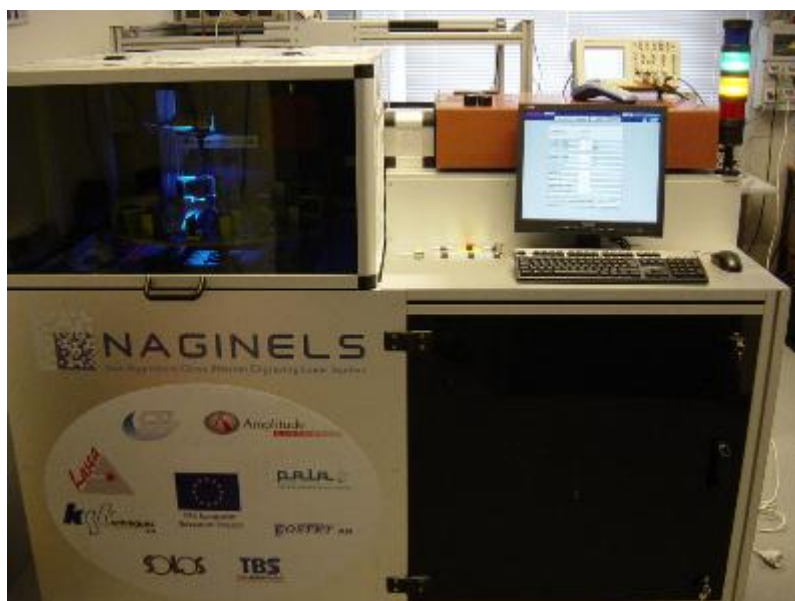
PLC valid states/transitions diagram

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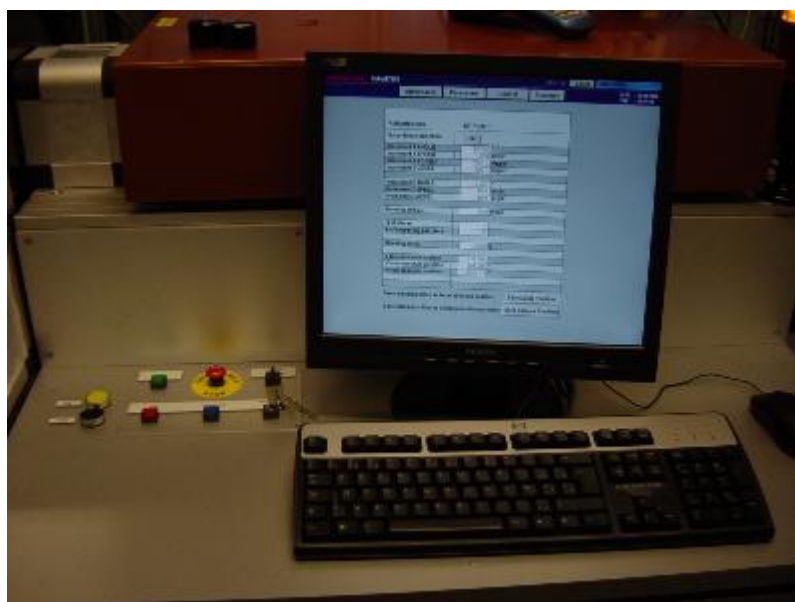
III.5.4 WP5.2 Construction of the prototype system

Prototype has been built in KST thanks to Lasea and Amplitude support.


Demonstration Unit – Photos :

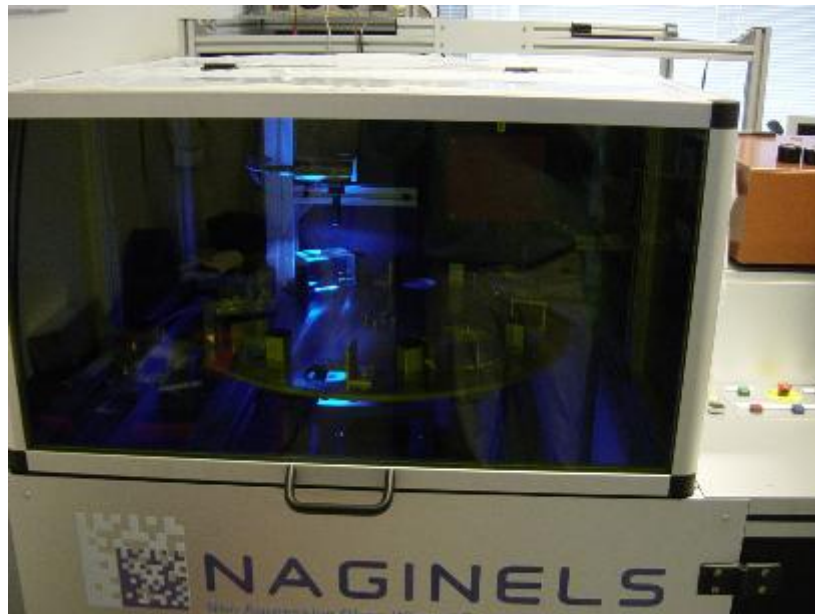


Demonstration unit – front view



Human machine interface (PC and control panel)

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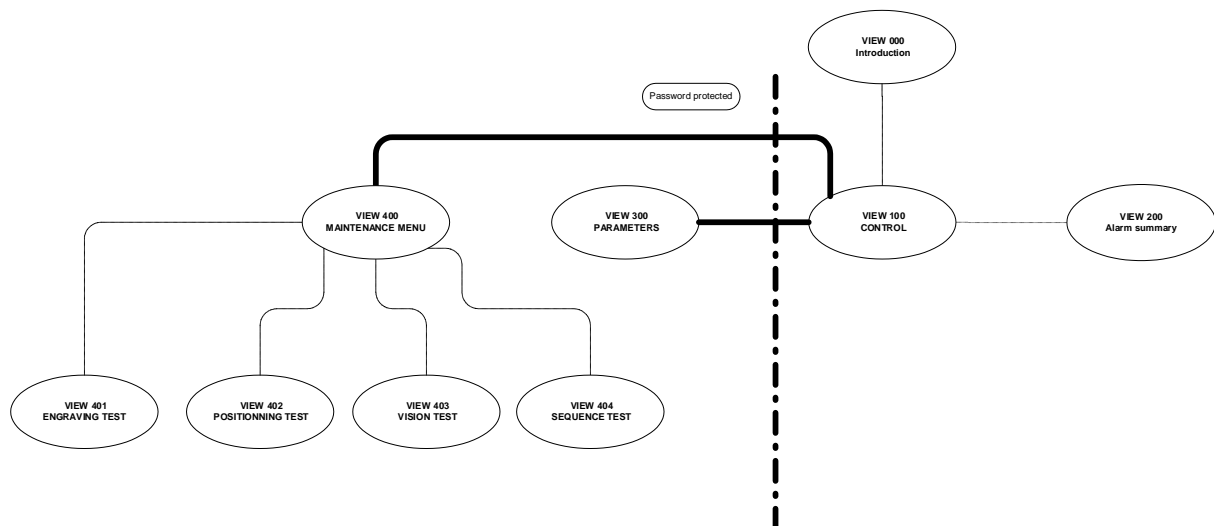


Indexed plate – laser/galva head/vision inspection


Just to illustrate a specific point, the human machine interface is described.

III.5.4.1 General tree structure

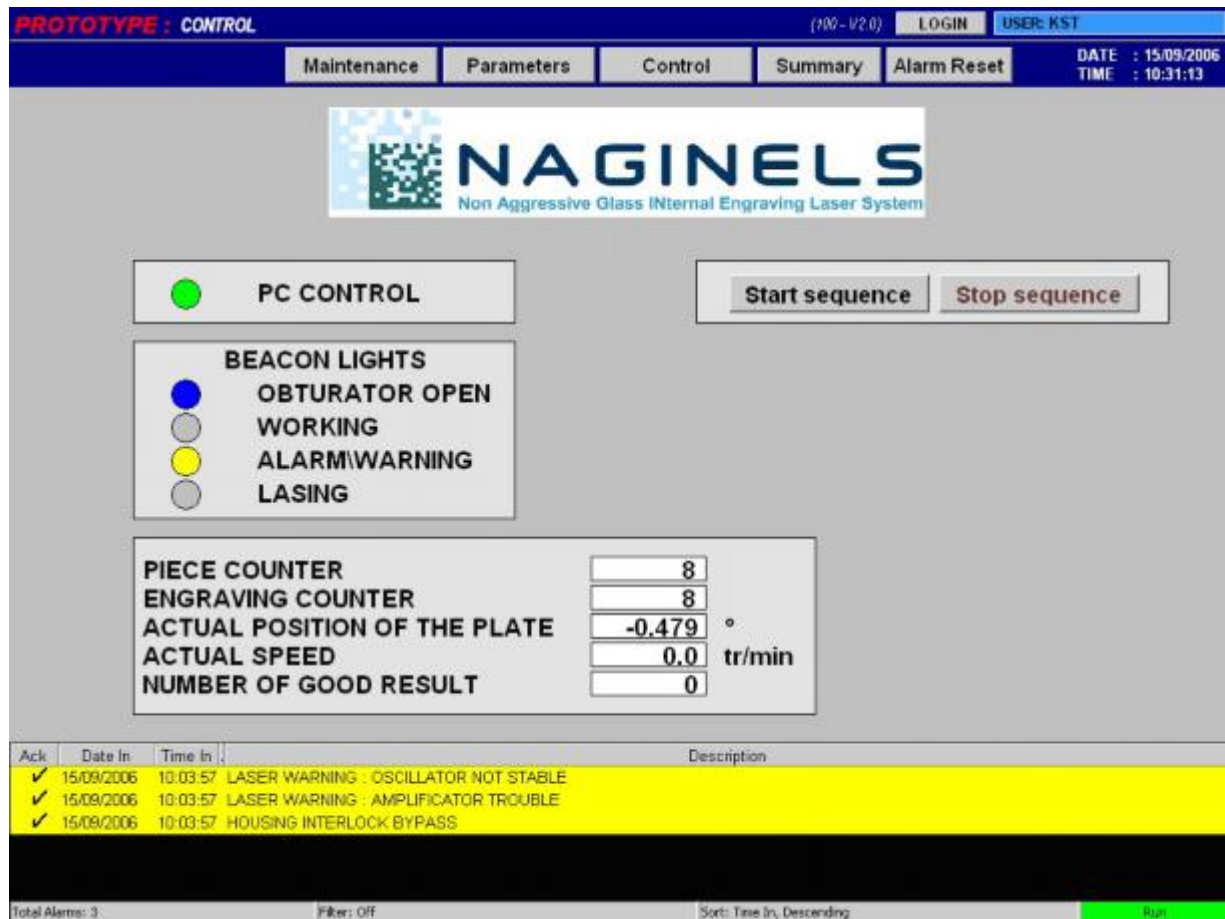
The tree structure of the human machine interface is configured as follow:



HMI – tree structure

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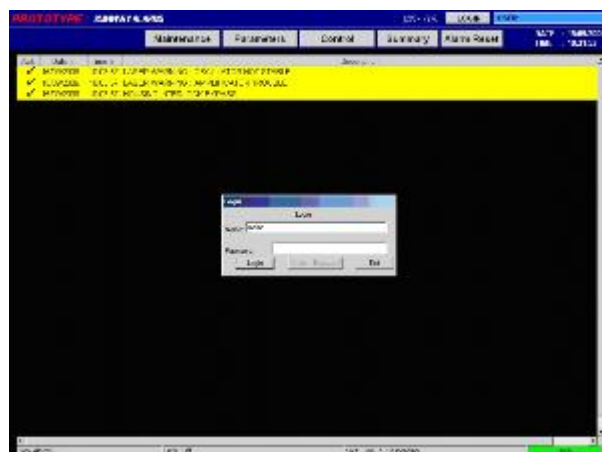
To illustrate how is configured the HMI interface, the following views shows the base of this environment (complete definition is available in the technical documentation set).



The screenshot shows the 'CONTROL' view of the NAGINELS HMI. At the top, there's a header bar with 'PROTOTYPE : CONTROL', version '(100 - V2.0)', a 'LOGIN' button, and 'USER: KST'. Below this is a navigation bar with buttons for 'Maintenance', 'Parameters', 'Control' (selected), 'Summary', and 'Alarm Reset'. The main area features the NAGINELS logo and a status section with 'PC CONTROL' (indicated by a green dot) and 'BEACON LIGHTS' (OBTURATOR OPEN, WORKING, ALARM/WARNING, LASING). A central panel displays various counters: 'PIECE COUNTER' (8), 'ENGRAVING COUNTER' (8), 'ACTUAL POSITION OF THE PLATE' (-0.479 °), 'ACTUAL SPEED' (0.0 tr/min), and 'NUMBER OF GOOD RESULT' (0). To the right are 'Start sequence' and 'Stop sequence' buttons. At the bottom, an alarm log table shows three entries from 15/09/2006 at 10:03:57: 'LASER WARNING : OSCILLATOR NOT STABLE', 'LASER WARNING : AMPLIFICATOR TROUBLE', and 'HOUSING INTERLOCK BYPASS'. The status bar at the very bottom indicates 'Total Alarms: 3', 'Filter: OFF', 'Sort: Time In, Descending', and a 'Run' button.

Control view

From every view, a login/logout action can be executed. Maintenance access is restricted to specific users.




This screenshot shows a 'Login' dialog box overlaid on the HMI interface. It contains a 'User Name' text field, a 'Password' text field, and 'Login' and 'Exit' buttons. The background shows the same HMI interface as the previous screenshot.

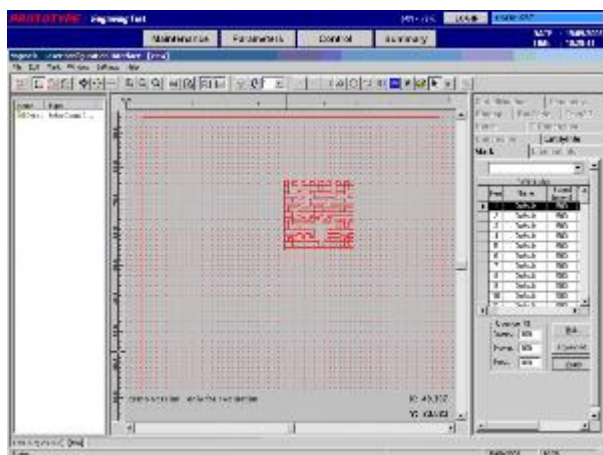
Login



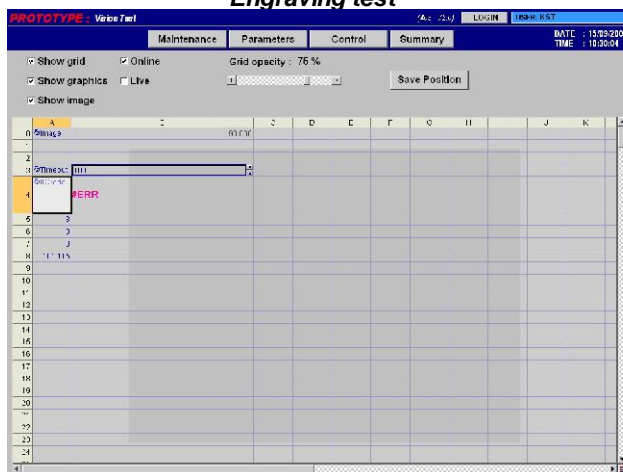
The screenshot shows the 'MAINTENANCE' view of the NAGINELS HMI. It features a navigation bar with 'Maintenance' (selected), 'Parameters', 'Control', 'Summary', and 'Alarm Reset'. The main area contains five large buttons: 'Engraving test', 'Piercing test', 'Validation', 'Sequence test', and 'Test light'.

Maintenance view

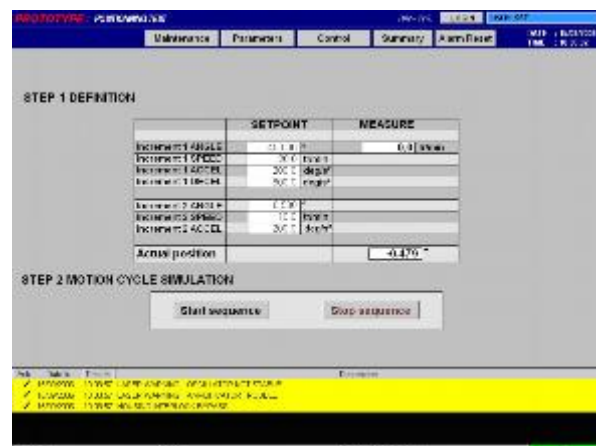
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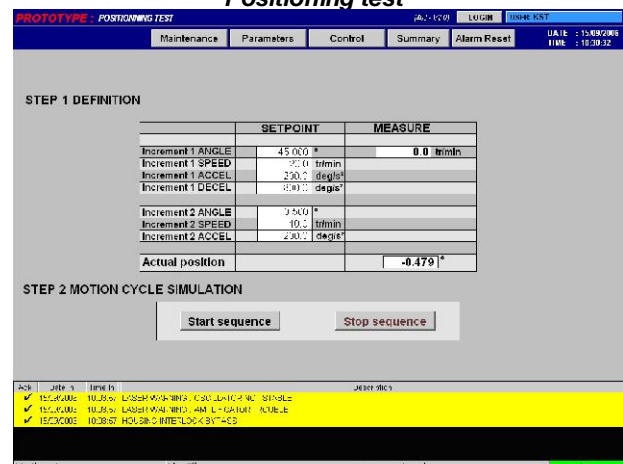
Engraving test



Vision test view



Positioning test



Positioning test view


After correct login validation, the operator can access the maintenance menu and select the following options:


- ü Engraving test.
- ü Positioning test.
- ü Vision test.
- ü Sequence test.
- ü Test light.

⇒ You can define speed and acceleration parameters in order to make a dynamic simulation of the sequence. The number of pieces and engraving are defined in the parameters screen.

⇒ For each increment, you can tune the speed, the acceleration and the deceleration.

⇒ The homing speed is the speed of the movement prior to every beginning of cycle. This is also the speed of the manual backward and forward movement

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PROTOTYPE: PARAMETERS (200-070) LOGIN USER: EST

Maintenance Parameters Control Summary


DATE: 15/05/2006 TIME: 10:30:34

PARAMETERS	SETPOINT
Increment 1 ANGLE	45.000°
Increment 1 SPEED	20.0 br/min
Increment 1 ACCEL	200.0 deg/s²
Increment 1 DECEL	500.0 deg/s²
Increment 2 ANGLE	0.500°
Increment 2 SPEED	10.0 br/min
Increment 2 ACCEL	200.0 deg/s²
Homing SPEED	2.0 br/min
# of pieces	8
# of engraving per piece	1
# of turn	
Laser absolute position	175.589°
Vision absolute position	211.716°
Actual absolute position	-0.478

Save actual position as laser absolute position Save Laser Position

Save actual position as camera absolute position Save Camera Position

Parameters view



PROTOTYPE: SUMMARY ALARMS (200-070) LOGIN USER: EST

Maintenance Parameters Control Summary Alarm Reset


DATE: 15/05/2006 TIME: 10:31:31

Ack	Date ts	Time ts	Description
✓	15/05/2006	10:35:57	LASER WARNING - OSCILLATOR NOT STABLE
✓	15/05/2006	10:35:57	LASER WARNING - AMPLIFIER TROUBLE
✓	15/05/2006	10:35:57	HOUSING INTERLOCK BYPASS

Total Alarms: 3 Power: Off Start Time: 0s, Depending Run

Alarm view

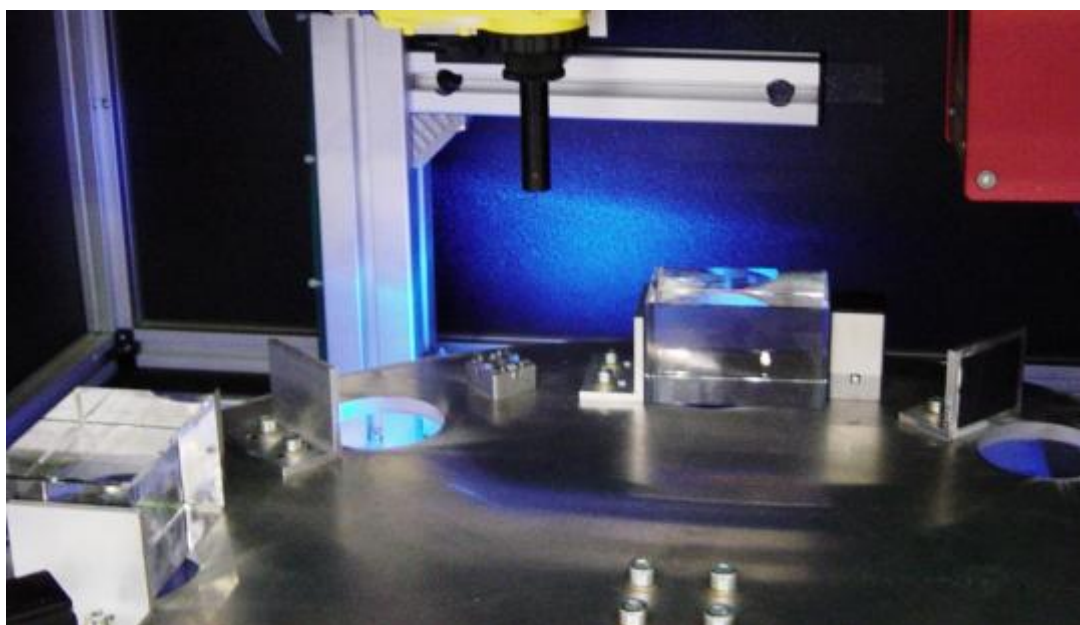
⇒ The alarm view summarizes all the alarms and warnings. You can acknowledge alarms and warnings with the alarm reset button.

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III.5.5 WP5.3 First validation using a set of referenced objects to be engraved

After the construction, a set of well calibrated experiments are performed using transparent objects. These tests have been made mainly on


- ü glass cubes 80 x 50 x50mm
- ü float glass
- ü perfume bottles



Engraving / reading tests on glass cubes

III.5.6 WP5.4 Support on the prototype at the beginning of the final tests

After the delivery of the prototype laser at LASEA laboratory, a support will be provided by KST and Amplitude in order to allow fine-tuning of the performance of the whole system. It will also avoid any problems of communication between the prototype engraving system and the index table used in WP6 to simulate a continuous manufacturing process.

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III.5.7 WP5.5 Risk Management


The work package was managed under the responsibility of KST. The project development logic for the development and manufacturing of the prototype was engaged in accordance with the following project methodology:

- Requirements definition.
- Basic engineering.
 - Equipment design.
 - Safety risk evaluation.
 - Process definition & Valid state / transition diagrams.
- Detailed engineering.
 - Mechanical & electrical documents.
 - Software detailed logic.
- Development and hardware construction phase.
 - Factory acceptance test phase / Site (LASEA) acceptance test phase.
- As built documentation.

This approach allowed a strong project management and communication between the four partners mainly involved in this WP :

- » KST / Costet for the application in fragrance (see deliverable 5.2 for details)
- » KST / Amplitude for communication / safety issue between control/command and laser
- » KST/Lasea for the issues linked to the engraving software, the reading system and the opto-mechanical issues

From the requirement step to the as built documentation step, the Naginels team working on this work package (WP5) put his energy to develop an equipment where the NAGINELS core can be validated. Thanks to the risk management, the goal was achieved within a reasonable timeline. The stand alone equipment is now a perfect tool to demonstrate all the power of this new engraving process.

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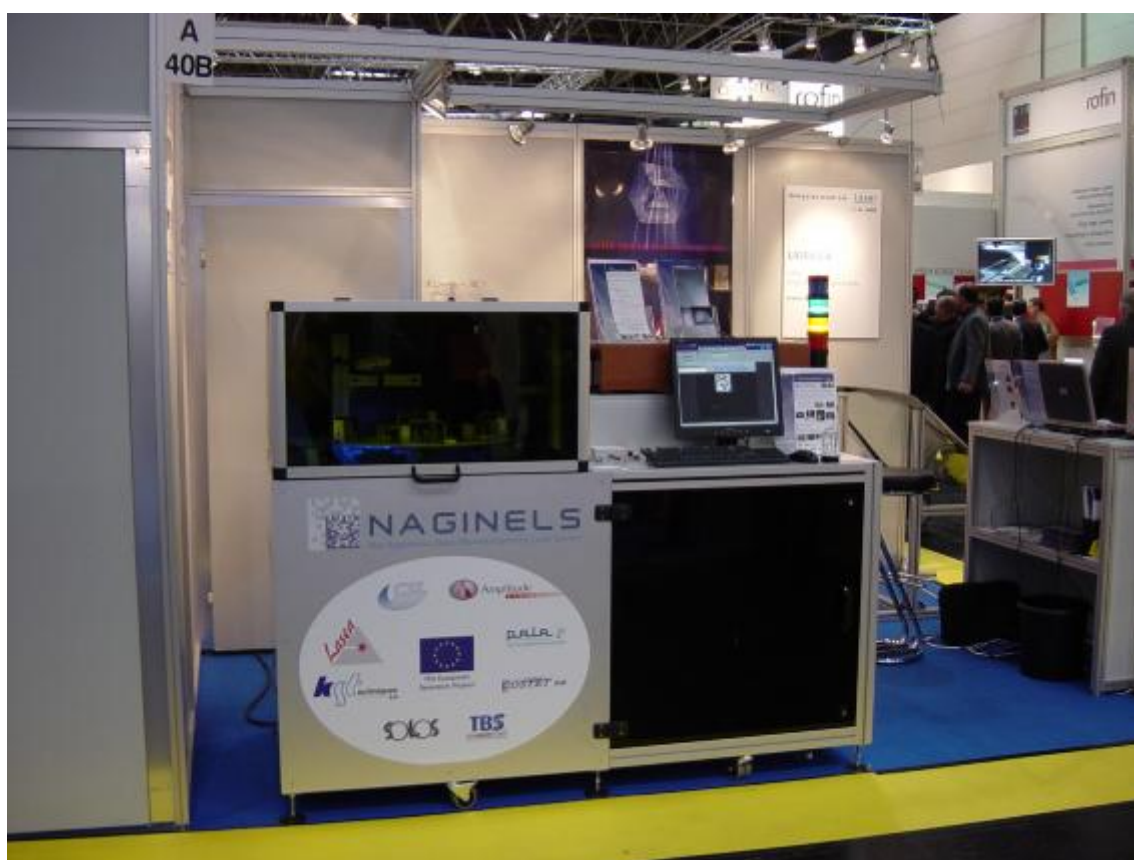
III.5.8 Conclusions


Thanks to the prototype, the following features of the new technology have been validated (WP6):

- ü speed and process time
- ü stability of the process
- ü engraving and reading
- ü vibration sensitivity

The application of the modules of the prototype (laser, galvahead, reading device, HMI) has been evaluated for fragrance, pharmaceutical & watches industries.

The prototype has been showed in Glasstec 2006, the worldwide tradefair for Glass Sector.



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III.6 WP6 Prototype validation

III.6.1 Work package flow chart

Seeing the late on the prototype delivery, a lot of final samples & real products have been treated thanks to the laboratory set-up.


- » The SMEs (Mainly Solos, Costet and TBS) have collected the different products from the end-users and sent them to Lasea.
- » First trials with the definitive subsystems (laser, galva head, and optical system) have been initiated in April. SMEs and end-users participated also to the treatments but no demonstration on site were organised for logistic and safety reasons. Demonstrations were organised in Glasstec 2006.
- » SMEs analysed the results on their samples: mainly Solos and TBS for pharmaceutical, luxury and beverage industries and Costet for Perfume industries.
- » Two end-users (Pilkington and GSK) made internal tests on their products to check the quality.
- » The final prototype arrived in Lasea only in July and main campaigns began in August after the start-up & optimisation phase of the prototype.
- » Then, high quantities of samples have been produced thanks to the index table of the prototype. Real process times, stability of performances and on-line reading verification have been checked. High stability was demonstrated (even in Glasstec show).

The WP6 meeting has taken place at Lasea, under the management of Lasea, on the 5th May 2006 at the beginning of the WP.

Two deliverables have been sent to the Commission in December 2006:

Deliverable No	Title
6.1	Field Tests Results
6.2	Final Results

The deliverable 6.2 summarized the features of the new technology (speed, quality, price and constraints).

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The results of the field tests are summarized in the deliverable 6.1. It is divided in 3 main parts.

- » Chapter II: Validation of optical systems on samples p 5
- » Chapter III: Key parameters p 8
- » Chapter IV: Tests performed p 13

The main points of these reports are summarized in the following task descriptions.

III.6.2 WP6.1: Final test specifications


III.6.2.1 Introduction

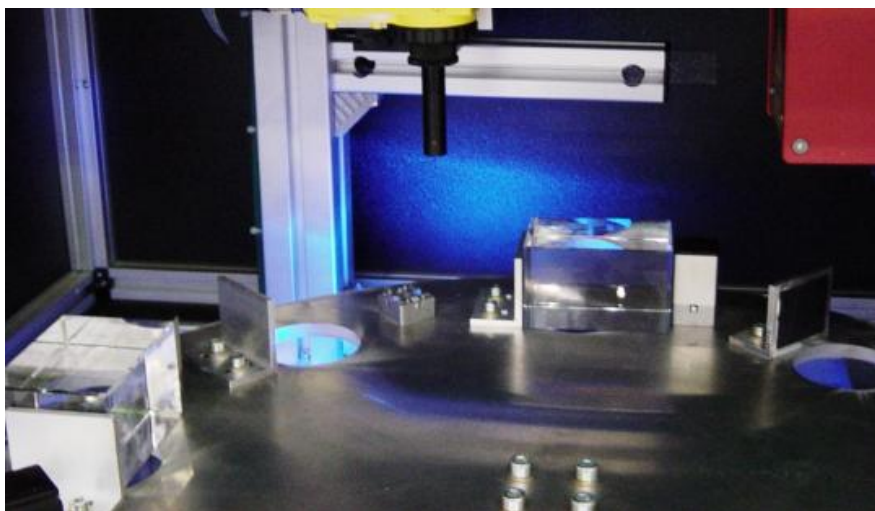
Based on the final test specifications (upgraded by the SMEs and the end-users during the task 4.4), Lasea began the treatments of many samples. Samples and products were collected by the SMEs.

More than one thousand engravings has been made on the different samples received from:

- Y Costet SA (perfume bottles)
- Y Solos (watches, bottles, pharmaceutical vials,...)
- Y TBS (bottles, pharmaceutical vials, sunglasses,...)
- Y The end-users:
 - U GSK : pharmaceutical vials, syringe
 - U Pilkington: float glass, toughened glass, special glass,...
 - U LVMH : perfume bottles

Moreover, glass cubes have been used to test the perfect stability of the engraving and reading processes, thousands engravings have been made in these cubes thanks to the prototypes. The stability of the process (100%) has been demonstrated (see our movie).

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Following the meetings with TBS, Costet and Solos, and products engraved, a specific campaign with analyses of the results by the CSL has been realized. In addition to the microscope analysis, products have been tested in:

- ü Heating cycle (up to 200°)
- ü Random vibration
- ü Ageing test with reading check

Products have been also sent to the End-users (Pilkington and GSK for internal analysis). No default has been found.


III.6.2.2 Final campaign on optical systems

III.6.2.2.1 Objectives of this test campaign

The main objective was to compare the results obtained in terms of diffraction quality using 4 different lenses, to be able to choose the best configuration for the final machine.

The 4 lenses used have the following characteristics:

Designation	Focal length	Design
F23	23	Microscope objective, anti-reflection coated
F30	30	Microscope objective, anti-reflection coated
F56S	56	F-Theta, anti-reflection coated
F56W	56	F-Theta, anti-reflection coated

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Lenses F56S and F56W have the same characteristics but are from two different lenses suppliers, the F56S being of very high quality.



Lenses (F23, F30, F56S, F56W)

Several matrices of parameters have been performed using these 4 lenses:

- Matrix of lines at several speeds
- Matrices of filled squares at several speeds and hatch
- Matrices of datamatrix at several speeds and hatch

III.6.2.2.2 Test Protocol

⇒ Matrices Realization


3 types of matrices have been realized to be able to compare the results.

The first type is a matrix of lines at several speeds and for the 4 lenses, as described in the following picture:

		Speed (mm/s)															
Lens	F23	50	100	200	300	400	500	600	800								
	F30	50	100	200	300	400	500	600	800								
	F56S	20	30	40	50	60	80	100	150	200	300	400	600	800			
	F56W	20	30	40	50	60	80	100	150	200	300	400	600	800			

Matrix of lines

The second type is a matrix of 1mmx1mm squares, depending on the sweeping speed and the hatching. The following matrix has been engraved for lenses F23 and F30.

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		Speed (mm/s)									
		100	200	300	400	500	600	800	1000		
Hatch (μm)	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

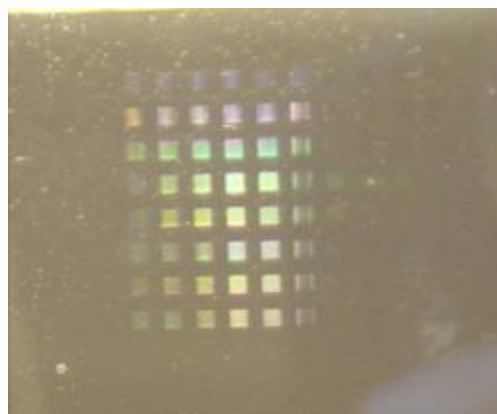
Matrix of squares (F23 and F30)

At these speeds, lenses F56S and F56W were not giving good results at all. Indeed the diffractive effect was extremely weak, and was replaced by a colour change, which seems to be caused by a larger spot size as explained in the previous report (D4.2).


Some tests have been performed at very low speeds and it appeared that results were a lot better. That is why for these 2 lenses, the following matrix has been applied:

		Speed (mm/s)											
		20	30	40	50	60	80	100	150	200	300		
Hatch (μm)	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Matrix of squares (F56S and F56W)



Matrix of squares

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III.6.2.2.3 Observations & microscope study

Using these matrices, it is very easy to choose the best parameters for each lens to obtain an optimum contrast:

Designation	Focal length	Hatch (µm)	Speed (mm/s)	Quality
F23	23	4	300	High
F30	30	4	300	High
F56S	56	4	50	High
F56W	56	5	30	Low

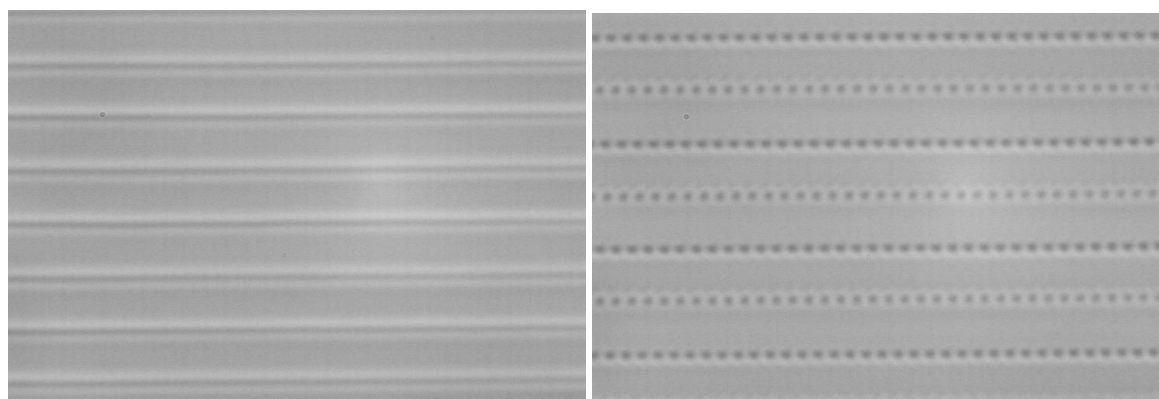
If we now compare the results between each lens, it is obvious that the F56W is not good enough to obtain a sufficient contrast. The effect obtain is mainly a colour change and the diffractive effect is almost invisible.

However for the 3 remaining lenses, the contrast is very high. The F56S has a higher colour change but the diffractive effect is of the same quality than the others.


For the F23 and F30, we have a good contrast on the whole 1mmx1mm square

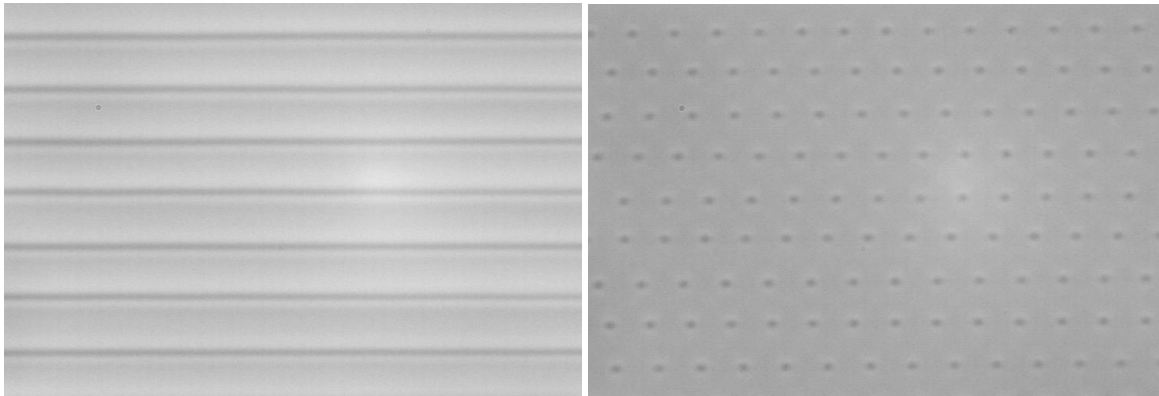
⇒ In terms of diffractive effect quality, the F56S is the most appropriate lens for the project.

With measures with a microscope we can confirm the results obtained in terms of diffraction quality. Very contrasted lines and points can be observed using lenses F23 and F30.



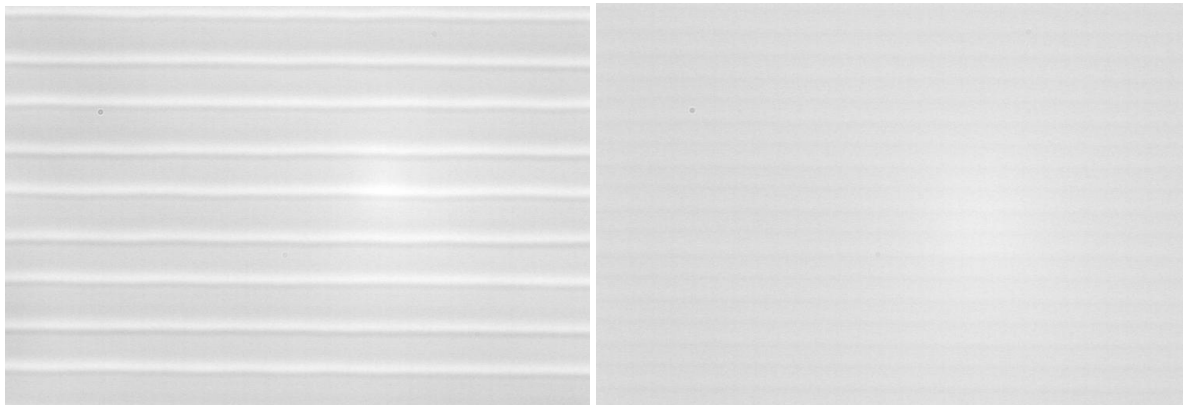
F23 at 100mm/s and 300mm/s

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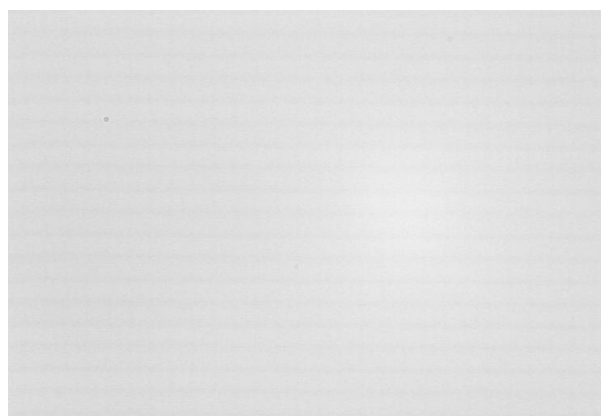
F30 at 100mm/s and 800mm/s

However for lens F56S, we have a good contrast at low speed, but at higher speed the pattern becomes blurred.




F56S at 20mm/s and 300mm/s

With the F56W, we have a blurred pattern even at low speed.



F56W at 20mm/s

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III.6.2.2.4 Comparison of the speeds

A good diffraction quality is not the only criterion to select the best lens for this application. To be integrated in a production line, the processing time has to be very low. The following table compares the marking times for lenses F23/F30 and F56S.

	Working distance	Working field	DM 1mm	DM 500µm	DM 250µm	DM 200µm	DM 100µm
F23/F30	21mm	1,6mm	1,4	0,6	0,28	0,24	0,13
F56S	67mm	12mm	2,9	1	0,37	0,28	0,14


We can see that for high dimensions squares, the difference becomes significant. The marking time for a 1mm² datamatrix is twice as high with the F56S. However for smaller codes, the difference is reduced and even negligible for 100µmx100µm codes.

Moreover the working distance for lens F56S is a lot higher than for the F23 and F30, which is a lot easier to integrate in an industrial process.

III.6.2.3 Conclusions on the Prototype configuration

These tests have been very useful to identify the best configuration for the optical system in the future machines. Moreover it let us identify a source of spot size increasing, the sweeping speed, which were not known previously.

- ⇒ The first observation is that a very high manufacturing quality of the lens is required to obtain good results.
- ⇒ Similar contrasts can be obtained with lenses F23, F30 and F56S.
- ⇒ As the working field of F23 and F30 is small (less than 4mm²) and that they do not have an F-Theta design, we do not obtain a homogeneous diffraction on a whole 1mm² square.
- ⇒ Marking times for F23 and F30 are lower than for F56S, however for small codes, this difference becomes negligible.
- ⇒ The working distance is higher for the F56S, which ensures a better integration in an industrial process.

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⇒ Thus, thanks to this test campaign, we have been able to choose the best lens for the prototype and field tests. This lens, the F56S, let us obtain good diffraction contrasts at high speeds, and with a high field of view (12x12 mm).

III.6.3 WP6.2 to 6.4: Final tests for the 3 applications

III.6.3.1 Introduction

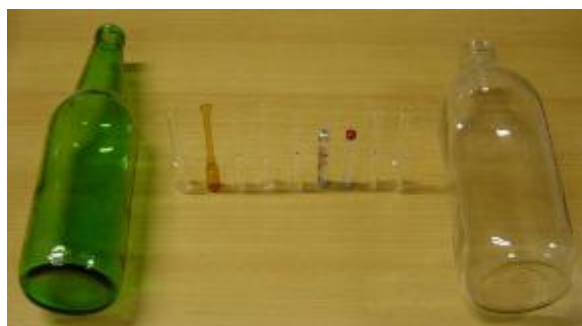
The second part of the WP 6 was focused on the field tests. They were divided in 3 parts in WP4 (see deliverable 4.3).

The field tests can be divided in 2 parts, depending on the surface quality of the glass treated:

- ⇒ Perfect surface quality: Pharmaceutical glass and float glass
- ⇒ Rough surface: Perfume bottles

Majority of the tests has been engraved with datamatrix (anticounterfeiting applications (#1 and #2)). Texts, logos,... have also been engraved for decorative and normative applications. The conclusions for cycle time and quality of engravings are similar as the ones detailed in the following chapters.


Each sample has been marked with datamatrix codes of 0.2x0.2mm, 0.5x0.5mm, and 1x1mm, and with Text of 1x1mm.



Bottles and vials



Watches

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Vials



Disks for mastering



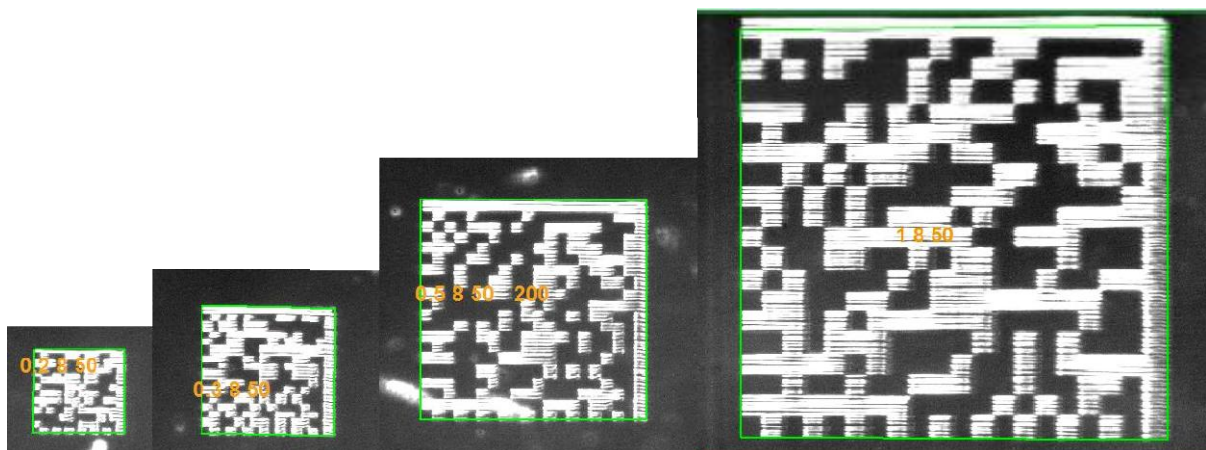
Perfume bottles

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III.6.3.2 Pharmaceutical vials and float glass



Pharmaceutical vials




Engravings in vials (0.2x0.2mm, 0.3x0.3mm, 0.5x0.5mm, 1x1mm)

On pharmaceutical glass or on float glass, the beam transmission until the focal point is almost perfect. That is why the depth has no influence if it is of the order of a millimetre.

For pharmaceutical applications, vial thicknesses do not exceed 1mm so the depth has not to be taken in consideration for contrast issues.

However in float glass, tests have been performed deeper. The diffractive effect disappears after 2 or 3 centimetres depending on the glass.

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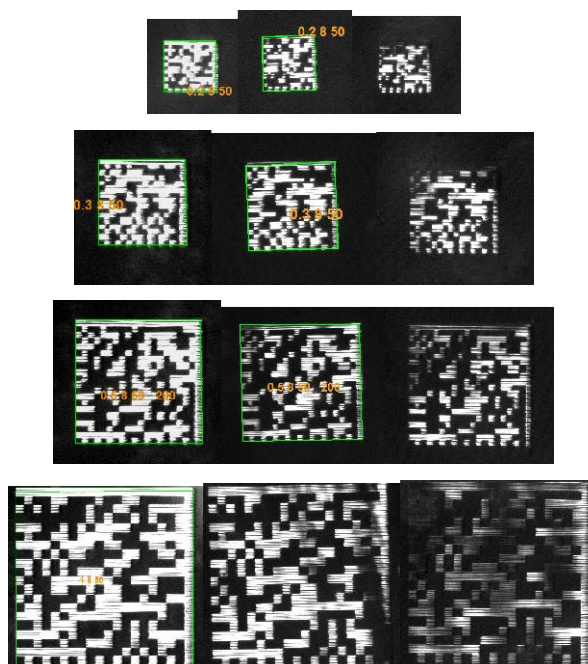
III.6.3.3 Perfume bottles

III.6.3.3.1 Good Surface Quality




Good surface quality samples

Picture shows some perfume bottles with high surface quality. These good surface qualities let us engrave codes up to 0.5mm deep without major readability problem.



Engravings of codes (0.2, 0.3, 0.5, & 1mm) at 0.1mm, 0.5mm, and 2mm deep

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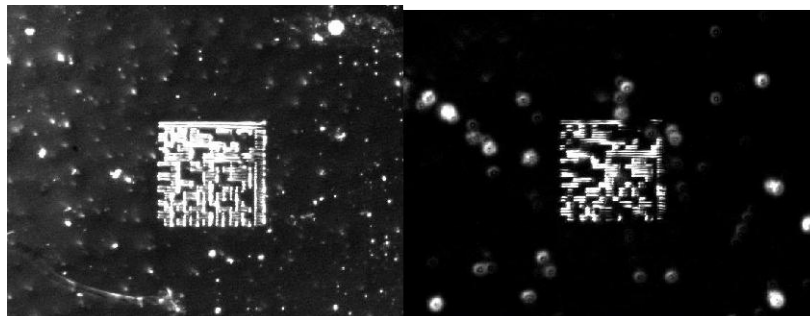
Text engraving (1x1mm) at 0.1mm deep

III.6.3.3.2 Low Surface Quality




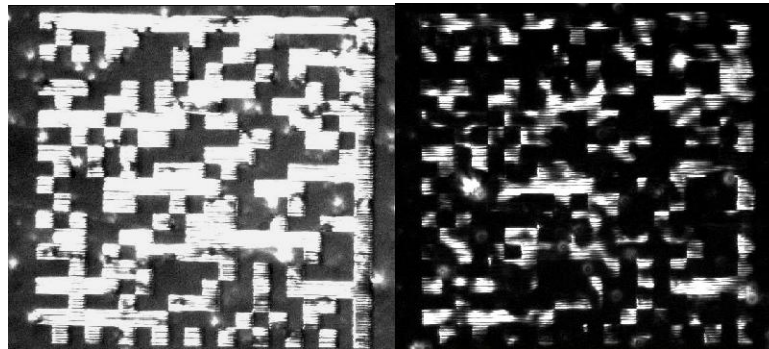
Low surface quality samples

The picture shows samples on which NAGINELS engravings are very difficult to perform due to a low surface quality.



0.3x0.3mm code at 0.1mm and 0.5mm deep

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1x1mm code at 0.1mm and 0.5mm deep


III.6.3.4 Coated and coloured glass



Coated or coloured samples

The main effect of a coloured coating is the absorption of the laser beam. If the absorption is low, such as the clear green coating, this effect is negligible. However if the colour is darker like the purple coating, a sufficient power is absorbed at the surface to burn the coating.

Another effect of a coating is that it homogenizes the surface so that the surface defects are minimized. Indeed although the surface quality does not seem to be high, average quality codes can be engrave at a 2mm depth.

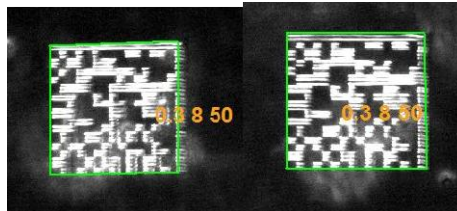
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III.6.3.4.1 Clear Green coating

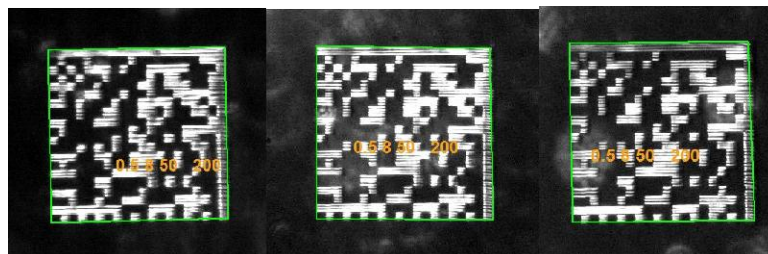
Thanks to this coating, surface roughness is reduced, which let us engrave codes up to 2mm deep. The interface between coating and glass is of course still rough but the difference of the index of refractions of both mediums is a lot smaller (less than 0.1 against ~0.5 without coating). This reduces refraction of the beam.



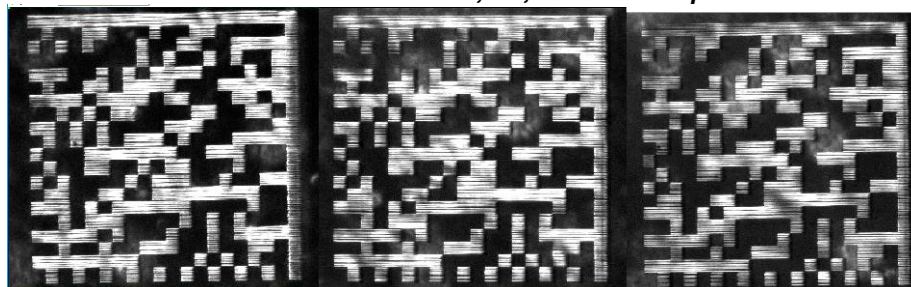
0.2x0.2mm code at 0.1, 0.5, and 2mm deep




0.3x0.3mm code at 0.1 and 0.5mm deep

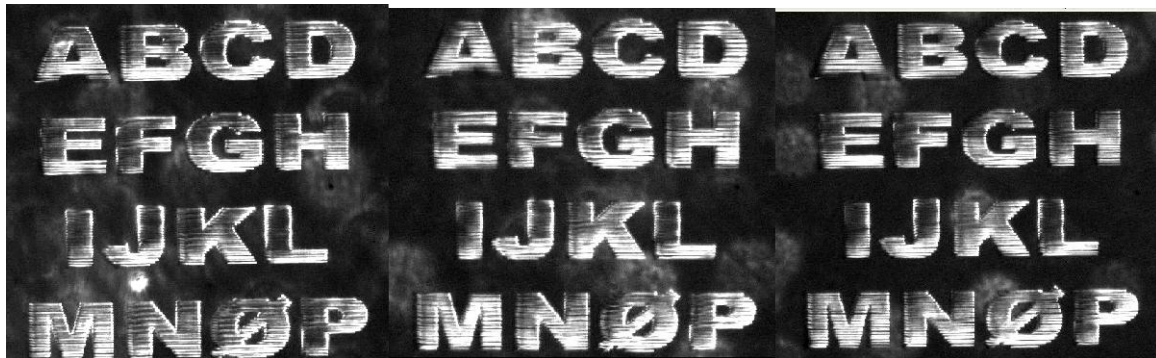


0.5x0.5mm code at 0.1, 0.5, and 2mm deep



1x1mm code at 0.1, 0.5, and 2mm deep

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Text at 0.1, 0.5, and 2mm deep

III.6.3.4.2 Dark and Opaque Coatings

Contrary to the previous coating, these ones absorb more light, so that this absorbed light is sufficient to burn the coating. Transmission of the beam cannot be perfect through these modifications of the surface properties.




Text engraved through a dark coating

The picture hereunder shows that the change of colour is efficient inside glass but no light diffraction can be observed.

Further tests have been performed under the following procedures:

- » Laser Clearing of the lacquer on a surface of 2x2 mm
- » In-depth Engraving in the zone where the lacquer was cleared.
- » Tests of readability.

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These tests were considered unsatisfactory, as the codes are read by a retro-lighting technique (indirect light). It is very difficult to be able to read the code engraved because of the weak lighting of the zone and thus a lack of contrast of the engraving

III.6.3.4.3 Colouration

For dark blue colour bottles, there is no coating but the absorption of the laser beam and of the lighting by the mass tinted glass itself lead to a very low contrast, even very close to the surface.




0.3mm code and 1mm text engraved at 0.1mm deep

The diffractive effect is not sufficient to catch enough light into the camera.

Tests were also carried out on black mass-tinted bottles. This type of colour has the characteristic of being very opaque. The tests of engraving in-depth are negative as the laser cannot penetrate inside the matter which is opaque to light. Further tests were thus launched in engraving on surface. These tests gave good results, thus opening the door to applications of engraving on the surface of opaque materials.



0.5x0.5mm surface engraving on black tinted glass

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III.6.3.5 Engraving on collar and carnets

Being that frosted and enamelled bottles cannot be engraved and that they have a zone of clear glass such as the collar and the carnets, tests were launched in order to verify the feasibility of engraving on this zone. The conclusions of the tests were negative being that the second reading of the code is impossible. The quality of glass on this zone is very bad. That is most certainly due to the strong pressure that is exerted by the glass moulds on this particular part of the bottle.

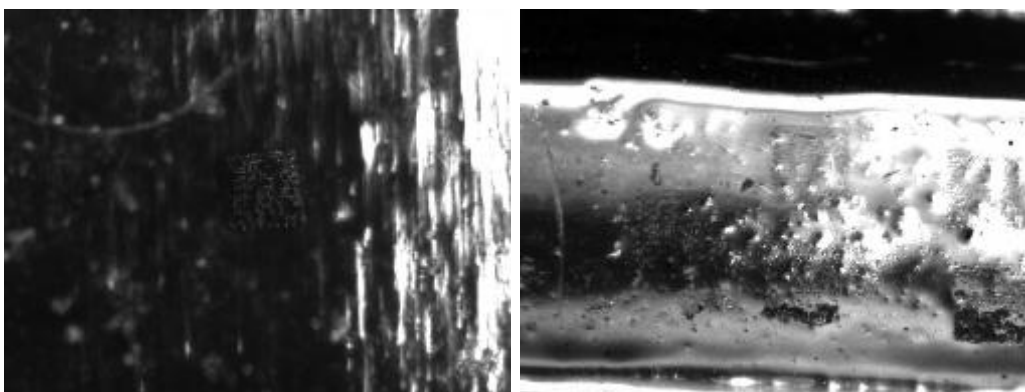



photo of the collar (left) and carnet (right) of the bottle – code is not readable

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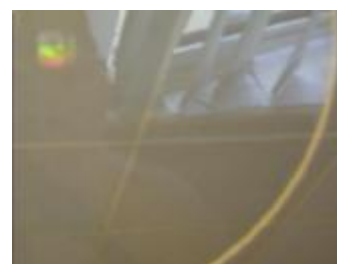
III.6.3.6 Summary of the results


As soon as the laser parameters are controlled, the depth of the engraving and the quality of the surface are the key parameters for the quality of the engravings (reading grade). The following tables summarized the quality of the different engravings:

		Depth	1x1mm 20x20 cells	0.5x0.5mm 20x20 cells	0.3x0.3mm 16x16 cells	0.2x0.2mm 14x14 cells
Pharmaceutical vials		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Float glass		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Watches glass		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G
Special glass for mastering		0.1mm	G	G	G	G
		0.5mm	G	G	G	G
		1mm	G	G	G	G
		2mm	G	G	G	G

Reading Quality: G=Good, A= Average, P=Poor, -=Unreadable

Reading quality vs glass type

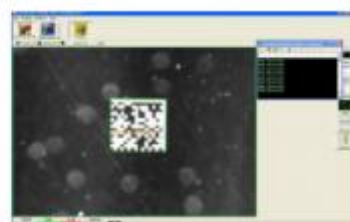



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		Depth	1x1mm 20x20 cells	0.5x0.5mm 20x20 cells	0.3x0.3mm 16x16 cells	0.2x0.2mm 14x14 cells
Perfume bottle s	Good Surface Quality	0.1mm	G	G	G	A
		0.5mm	P	A	A	A
		1mm	P	A	A	A
		2mm	P	P	P	P
	Low Surface Quality	0.1mm	P	P	P	P
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-
	Clear Green coating	0.1mm	A	A	A	A
		0.5mm	A	A	A	A
		1mm	A	A	A	A
		2mm	A	A	A	A
	Dark and Opaque Coatings	0.1mm	-	-	-	-
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-
	Coloured	0.1mm	P	P	P	P
		0.5mm	-	-	-	-
		1mm	-	-	-	-
		2mm	-	-	-	-

Reading Quality: G=Good, A= Average, P=Poor, -=Unreadable

Reading quality vs perfume bottle type



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III.6.4 WP6.5: Recommendations for the industrial units

In addition to the reports made by:

- TBS and SOLOS (see Deliverable 1.3 chapter III) on anticounterfeiting application
- Costet (see Deliverable 1.3 chapter II & IV & and chapter IV in Deliverable 5.1) on decorative application
- KST (see Deliverable 1.3 chapter III) on normative application,

the tests realized in the tasks 6.1 & 6.2 to 6.4 have shown the following constraints of the process:

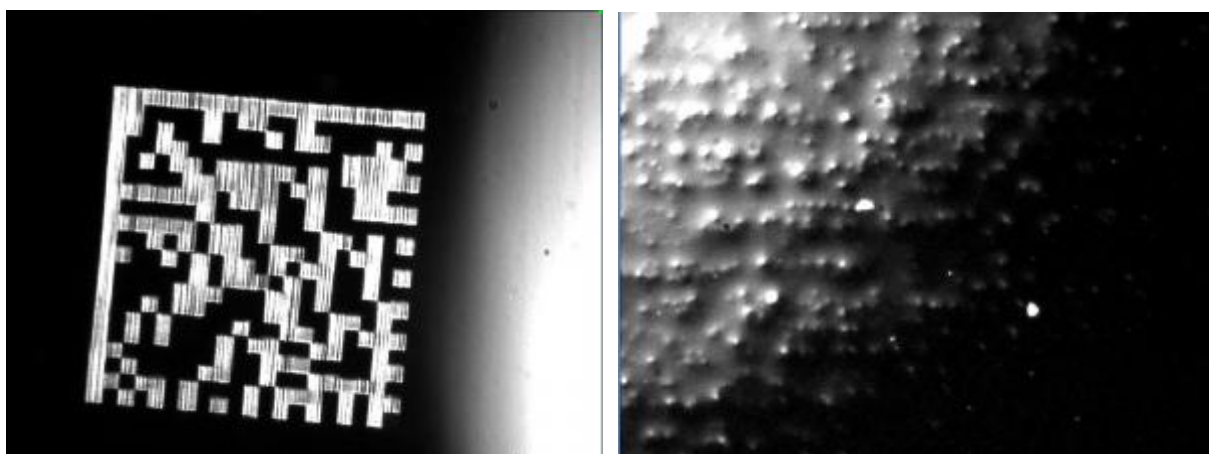
- » Surface quality of the products
- » Curvature
- » Tolerance
- » Engraving parameters (type of engraving, speed, capacity)

They are detailed below.


III.6.4.1 Surface Quality

Surface roughness is probably the **main limitative parameter** in this project. Indeed while a perfect surface quality like float glass or pharmaceutical glass gives very contrasted and homogeneous results, roughness of moulded bottles can cause parasite reflections and beam deviations leading to lower readability.

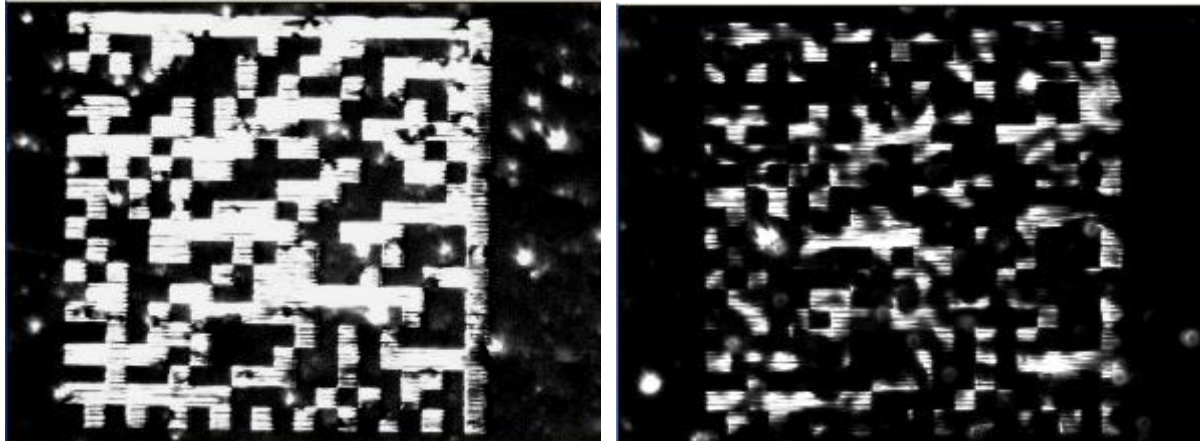
The left picture shows a perfect quality glass. We can see that no surface roughness can be seen in the lighting area on the right, contrary to a lower quality glass, on which roughness is easily visible.



Surface quality of pharmaceutical Glass (a) and perfume bottle glass (b)

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The following pictures show the same glass as the previous one (part b), with 1x1mm datamatrix engraved respectively at 0.1mm and 0.5mm depths.



Datamatrix engraved in a low surface quality glass at 0.1mm deep (a) and 0.5mm deep (b)

In part a, as the surface is near the focal plane, every defects on the surface are visible. This leads to reflections, which make the identification of the code more difficult.

In part b, surface defects are less visible because the focal plane is deeper in glass, but surface defects lead to beam deviations because of refraction laws. The diffractive effect due to the precise positioning of engraved lines is then lost, as the lines are not straight anymore.


⇒ That is why a high surface quality is necessary to reach a high rate of readability.

III.6.4.2 Curvature

One other possible influence of a sample on the marking was its radius of curvature. Indeed the curvature between two mediums of different index of refraction acts like a lens.

Let us take the example of a pharmaceutical vial, which can have a radius of curvature as low as 5mm and a 0.2x0.2mm code engraved at 0.1mm depth. The difference in height between the centre of the surface exposed and the border is of only 1µm. Therefore it is easy to admit that the curvature is negligible in front of such a small code.

However for a 1x1mm code, this height difference is of 25µm. This lead to a small refraction, but the shape transformation is not visible.

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Engraving of a 1x1mm code in a pharmaceutical vial

Regarding larger bottles, like perfume bottles, which have a radius of curvature of at least 20mm, the curvature with a code of 1x1mm lead to a height difference of 4µm. The refraction due to curvature can also be neglected.


That is why the shape of bottles **does not have any effect** on the feasibility or the quality of the engraving. The bottles of various forms are treated in the same way.

III.6.4.3 Tolerances concerning the dimension of the bottle:

Tests have shown that the exterior dimensions of a bottle caused problems when engraved: The position of engraving changes in-depth in important proportions. The analyses of the bottles technical plan give an explanation: Some dimensional measurements indicate tolerances of approximately +/- 0.8mm. Bottles thus have a variable position compared to the laser. Certain bottles are positioned closer to the laser and have an engraving more in-depth than the defined measurement. Certain bottles are positioned farther away from the laser and thus are not engraved because the laser's beam misses the bottle. Being that the depth of the engraving is defined at 0.5 mm within the surface and that the tolerance of the bottles can reach +/- 0.8 mm, it is possible that the laser positions itself: In-depth at: 1.3 mm from the surface and from the exterior of the bottle: 0.3 mm.

A solution must be brought to this critical problem because it is impossible to be able to manage it in production with the current tolerances of the perfume bottles and the general tolerances defined by the hollow glass bottle manufacturers. The production machine tool will have to integrate a function of measurement of the bottles with a **system of compensation** which will make it possible to position the bottles at a constant distance in relation to the laser.

» See report on WP5/paragraph Dubuit machine. & bottle plan for operetta 100 ml/SGD

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III.6.4.4 Source of the bottles

The tests were carried out on bottles from various glass suppliers. The results showed that there is ***no difference in quality*** of the laser engraving between the suppliers. The most outstanding difference comes from the surface quality of glass which varies quite importantly from one glassmaker to another. Even though some glassmakers are more specialized in the production of top-of-the-range bottles with a standard “fire polished” treatment, this does not necessarily mean that their bottle is more compatible with the Naginels laser treatment. In fact it is rather the fire polishing treatment that improves the code readability, but the fire polishing treatment should not be an added step in the process of Naginels engraving on the perfume bottles.

III.6.4.5 Engraving parameters

Engraving parameters, such as the speed or the hatching, do not depend on the engraving depth or other sample particularities.

2 types of codes were tested at the time of the various Code tests:

- ü Data Matrix Codes
- ü Numerical Alpha Codes


The constraints explained above show that in some cases the readings of the codes can be affected by the quality of glass.

The imperfections on the surface (Striations, Grainy aspect, Folds, Air bubbles on surface) or in the material (Air bubbles in glass) can influence the laser at the time of engraving or on the camera at the time of the reading.

Datamatrix Codes are read thanks to software which requires a certain quality of the engraving to be able to identify the code.

The tests showed that in certain cases reading was not good and, at times impossible.

Other tests were also carried out in a Numerical Alpha format. This type of code gives a greater tolerance on the reading process because the reading is done by the naked eye and not via software which requires a minimum quality of engraving.

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data matrix code and alpha numerical code

Large codes (down to 1x1mm) can be read with a magnifying glass with an enlargement of 15x. For the smallest codes starting from 0.5 mm, the standard camera for second reading tool VS030 created by Lasea is necessary.


As shown in the following table, the code capacity has a very low influence on the marking time. However for 0.3x0.3mm and 0.2x0.2mm, maximum capacities are respectively 16x16 and 14x14 to reach a high readability. For 0.5x0.5mm and 1x1mm, capacity can go up to 20x20 cells.

Datamatrix	Code capacity	Time
1x1mm	20x20	1.74s
1x1mm	16x16	1.68s
0.5x0.5mm	20x20	0.48s
0.5x0.5mm	16x16	0.47s
0.3x0.3mm	16x16	0.19s
0.2x0.2mm	14x14	0.1s

Text	Code capacity	Time
1x1mm	16 characters	1.03s
0.5x0.5mm	16 characters	0.29s
0.3x0.3mm	16 characters	0.13s

Code capacity vs cycle time

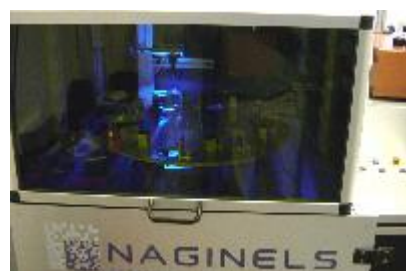
As Naginels engraving is miniaturized and invisible, its automatic second reading at high rate is impossible once it leaves the engraving machine.

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End-users have confirmed that the reading of the codes would be limited to the verification and appraisal of the bottles. As this type of verification is rather limited in quantity, a manual second reading is thus possible. Moreover, the time factor is not critical in this function of appraisal.

III.6.5 WP6.6: Contribution for the PUDK

Thanks to the WP6, the technology is now validated. The main constraints are under controlled and had contributed in the PUDK (see Deliverable 8.6). The prototype has demonstrated the stability of the process and has been showed during Glasstec 2006. Solos, TBS and Lasea made the demonstrations to their customers and to the visitors during one week in this event..




NAGINELS Prototype

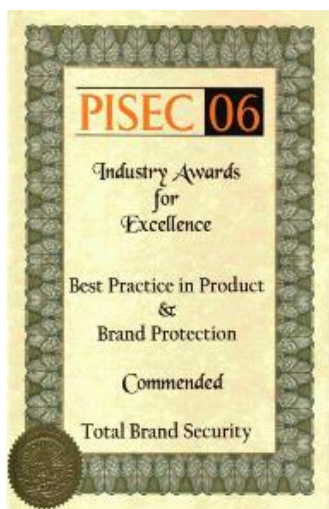
Lasea and PALA have shown the samples to the Micronora fair trade in France.

Solos has shown the samples and demonstrations of the reading systems during conferences in Roma.

TBS have shown the samples, the movie, and made demonstrations of the reading systems during conferences in London.

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TBS and SOLOS have also presented the technology in PISEC 2006 - Barcelona. Amplitude participates also to the conference. Our technology has there received an award for excellence




A new company has to be created in the following weeks for the industrial phase of this new technology and the commercialization. The partners have to work now on the reduction of price of this high level laser system and on the possibility of a quick integration of the technology in one of the end-user's plant.

III.6.6 WP6.7: Risk management

WP6 was carried out under the responsibility of Lasea SA. One meeting held in Lasea in May 2006, but results were discussed during SB meetings of July 2006 and October 2006. Thanks to detailed exchanges between the SMEs (mainly SOLOS, TBS and COSTET) and Lasea, products have been treated and analysed during this workpackages. Visits of end-users with the SMEs in Lasea for demonstration allowed a strong understanding of the needs of industrial customers. The help of KST and Amplitude to optimize the prototype was very quick. Thanks to this management, samples, prototype and results were ready for the official presentation of the technology during the three exhibitions of October and November:


- » PISEC (Barcelona)
- » Glasstec (Düsseldorf)
- » IPQC (London)

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III.6.7 Conclusions

This test campaign has let us validate NAGINELS engravings on real samples for pharmaceutical and luxury industry.

- ü As soon as the parameters are controlled for a piece, the process is very stable for the engraving as well as for the reading.
 - ü Cycle time and capacity of the codes are on-line with our targets and market needs
- ⇒ It appeared that the main limitative factor is the **surface quality of glass**: a rough surface create parasite reflections and beam deviations leading to barely readable codes.
 - ü Average quality glass can be engraved near the surface (up to ~0.4mm) to obtain reliable readings.
 - ü Pharmaceutical samples and float glass, due to their high surface quality, do not pose any problem.
 - Ÿ Coated or coloured samples seem to be impossible to engrave if the colour is dark.
 - ü Clear coatings offer a homogenization of the surface, which offers a larger depth area to perform the engravings.
 - ü Miniaturized surface engraving may be applied for opaque coloured bottles.
- » To obtain good results on most of the samples, a precise positioning is necessary, so that the depth of the engraving can be controlled at +/- 0.1mm. As the perfume bottle do not present this kind of precision on their outside dimensions, it is necessary to add to the machine a positioning sensor to ensure the exact distance between the laser head and sample surfaces.
- » Demonstrations, conferences and seminars on the technologies are possible thanks to the prototype, the video files, and the samples.

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III.7 WP7 Dissemination of results

III.7.1 Work package flow chart

Dissemination of results issues have been discussed as soon as the beginning of the project. Confidentiality agreements have been created for end-users and potential customers. Seeing the results were very good, PUDK was discussed in all next meetings and a patent deposit was envisaged. SB decide to postpone the web site. Naginels website was available in May. It was decided to create three new tasks in this WP:

- a WP7.6 Patent
- a WP7.7 Norms
- a WP7.8 Other press releases and seminars

Seeing the patent, the consortium decided not to allow scientific papers seeing the confidentiality needs.

All the partners written articles and organised seminars:

The technology was presented in Glasstec 2006. Potential customers and end-users were invited and demonstrations were organised during one week.

III.7.2 WP7.1: Project web site construction


Following the decisions of SBB in October 2004, we have postponed the web site construction in order to keep confidential data and have the opportunity to deposit a patent in the future. In January, Lasea begin the construction of the web site. Two main parts have been created:

1. A part for potential customer
2. A restrictive part for members of Consortium.

Lasea have made html pages but to have a very powerful web site, we decide to make dynamic pages with dynamic modules to be more efficient in term of marketing and Consortium management. These modules were not initially schedule and Lasea have not the competencies to make dynamic modules that's why Synchrone, a subcontractor was chosen for this job. References and domain register were also added.

The web site is www.naginels.com.

We also create a logo for the project:

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All partners have participated in the design of the NAGINELS web site in collaboration with LASEA. This task has required close exchanges, especially under the form of telephone conferences with the different NAGINELS partners.

III.7.2.1 Non restrictive part


Page 1: Presentation



Page 2-4: Applications



» Link to the European Commission and partners have been activated, as well as e-mail address info@naginel.com

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Page 5: Links



» Link to the European Commission, Cordis and partners have been activated

Page 6 : News => Dynamic module allowing to write news, download files,...




Page 7 : Contact => Dynamic module allowing to have the contact names and requests

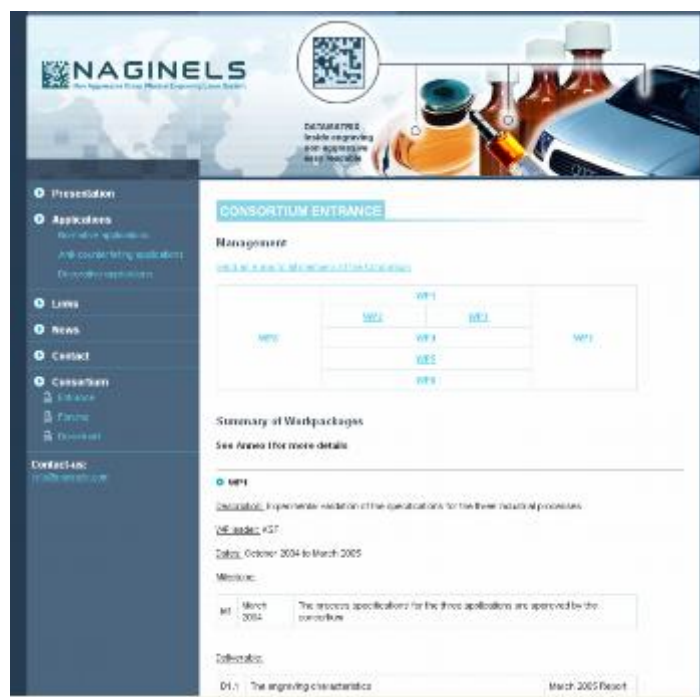


III.7.2.2 Restrictive part

This part is the core of the management of the Consortium. Each partner has its own login and password

The first page “**Consortium entrance**” is the summary of Workpackages, planning, and deliverables to send to the Commission. In each WP, e-mail communication is facilitated by automatic (to, cc) for each task or work package) avoiding to e-mail technical information to each member all the time.

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Link to each WPs and details + send an e-mail to all members


The second page “**Forums**” is dedicated to restrictive news between the members of the Consortium. Each member may write news and reply to another.



The last page “**Download**” is dedicated to the shared documents: documents from the Commission, templates, deliverables, meeting minutes...

III.7.2.3 Administrative part

This part allows creating news, seeing the contacts, managing the documents and categories, the forum and the user’s management.

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III.7.4 WP7.3: Concluding seminar on the project


Naginels exhibited on Glasstec, the World's largest Glass Trade Fair from 24th to 28th October 2006 (booth 11A40 B). This was very important as the leading glass manufacturers of the world attend this global fair and so do their major customers.



Prototype was shown for the first time. Demonstrations of the machine and the reading systems were organized. Potential customers and end-users were invited.

All the partners participated to the exhibition (the second day, the last SB meeting was organised in a meeting room in the exhibition fair). Solos and TBS stayed with Lasea during all the fair. Glasstec received more than 55.000 visitors which more than 150 visited our booth. We got over 20 important leads all over the world for the Naginels concept which we are following up on.



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III.7.5 WP7.4: Recommendations for the use of femto laser engravings in the antifraud field

In addition to the reports made by TBS and SOLOS (see Deliverable 1.3 chapter III) on anticounterfeiting application many articles and seminars have been organised by Solos and TBS, mainly to show the interest of this new technology for anticounterfeiting issues.


The Naginels technology is of great interest to many different market segments and therefore the strategy behind disseminating the results as efficiently as possible has been multi pronged. The main markets of interest are the following;

- ü Pharmaceutical
- ü Perfume and cosmetics
- ü Wines and spirits
- ü Watches
- ü Precious stones —diamonds etc
- ü Automotive
- ü The glass industry

Each of these industries have their own specific strategies of market penetration and each of these markets were addressed using the following;

- » Insertion into specialized press publications;
<http://www.iom3.org/pp/may06/news.htm>
- » Using global news services for examples;
http://presszoom.com/story_118356.html
- » Direct e-mail directly to specialized responsible
- » Applications for industry specific awards -- see below
- » Inclusion of Naginels specific search words in Internet search engines
example – type “Naginels” into Google
- » Inclusion into the consortium member websites
- » Participation in conferences
- » Individual customer visits and presentations
- » Individual seminars to groups of customers
- » Participation in Congresses and specialized forums

The most important independent way to address the specialized press is to make use of specialized reporters that can write independent articles describing the features advantages

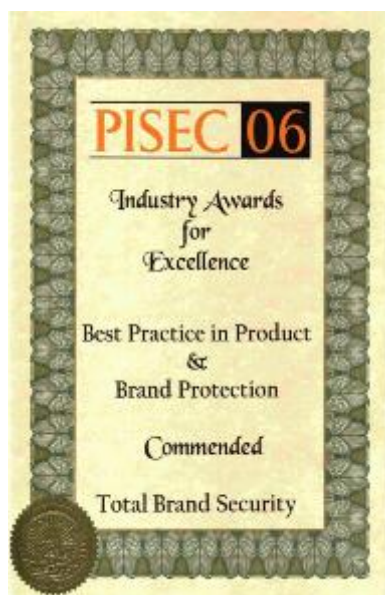
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and benefits of the Naginels technology. This was successful in the following publications (see some examples below);

- ü Brand security “Future of Laser Marking in Perfumes”
- ü Product and Image Security see below
- ü Brand protection news see below
- ü Financial Times – yet to be published
- ü ...

See our web site: www.naginels.com/news


The first world introduction of the Naginels concept was at the **PISEC Barcelona Congress** – a world authority on everything related to brand protection. See below for the Congress agenda and Naginels presentation. The result of this was winning an award for Naginels:



An industry specific presentation of Naginels was made at the **IQPC in London**. This was attended by all the leading pharmaceutical companies around the world and a booth was made up and presented by Total Brand Security Ltd. We presented using a booth together with other leading technology providers directed towards the pharmaceutical industry.

Individual customer presentations have been carried out to customers such as;

- ü YSL
- ü Chanel
- ü Cartier
- ü Novartis
- ü Glaxo SmithKline
- ü

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III.7.6 WP7.5: Risk management of the work package

Workpackage 7 is, as WP8 (management), a continuous workpackage involving all the partners. The web site is an important tool for management of information. Control of the diffusion of information was the most difficult issue in order to show the results to the scientific community and to the potential customers without risks for the patent. All the information linked to the PUDK were discussed during each of the nine SB meeting. For instance, the SB has decided:

- to deposit the patent
- to add 3 tasks to the workpackage
- not to allow scientific papers
- ...

Through the management of TBS, the information in the articles and seminars were under controlled. At the end of the project, a lot of seminars and conferences were organised in Europe on Naginels technology. The technology was also presented to 4 main exhibitions (Micronora - Grenoble, PISEC - Barcelona, Glasstec - Düsseldorf, IQPC - London)


III.7.7 WP7.6: Patent

This task was not foreseen in the initial project but the results were so good that a patent protection was discussed at the end of 2004. The decision was taken by the SBB in June in Bordeaux and confirmed during the SBB meeting in Liège in July. The patent was prepared by Amplitude (laser source) and Lasea (process), and reviewed by each of the SMEs partner. The patent was deposited the 28 September 2005 under the reference 01803916.2.

The title is: *“Procédé de marquage interne par laser dans les matériaux transparents et laser et dispositif utilisés pour l'application de ce procédé”*.

The patent has 37 claims, 44 pages of description including the pre-existing know-how of the two RTDs companies.

Lasea and Amplitude worked also in September 2006 on the results of anteriority study and on the PCT version and on new claims for this patent.

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III.7.8 WP7.7: Norms

III.7.8.1 Introduction

After a short presentation of NAGINELS project in VINEXPO 2005 meeting (June), PALA participated to a workshop on anti-counterfeiting techniques. The meeting was animated by the Director of the French *Imprimerie Nationale*, and the responsible of the French ACCORD project (launched by the French government in June 2004). After this meeting, NAGINELS consortium suggested that Costet (as an end-user) should meet the ACCORD responsables in August 2005 to give a more comprehensive presentation of NAGINELS project. It appeared quite clever that NAGINELS process could meet ACCORD normative requirements. Since June, SB took the decision to create a new task in order to enter in the specifications of the ACCORD norm which will be active in France since the 1st January 2006 and extended in European Union the year after. In one hand, Costet has had a lot of meetings with the people and companies involved in the new anti-counterfeiting norm. In the other end, SOLOS, KST and TBS create strong links with companies involved in protective number (like Kessler codes). The director of Kessler was invited in the Consortium meeting of September in Epone.


III.7.8.2 The follow-up of the Norm



Our main objective was to see if the norm Accord would be compatible with the development of our Naginel's program and what we would have to do during our research program in order to be validated by this new norm.

The creation of a new norm would be a very important event that would influence the direction of our work in order to be sure that we could be homologated for the future commercial use of the technology.

The first meeting was held on July 27, 2005 in Paris at Imprimerie Nationale with Mr. Delval and Xavier Costet. He presented the Consortium Naginels and explained our objectives in counterfeiting as well as track and trace applications. He also showed a sample of vial bottles engraved with several data matrix codes in different sizes.

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Mr. Delval was very interested in our consortium and he asked a presentation of our work. The French government wants to implement a strong policy to fight counterfeiting. This program could be resumed as this :

1/ Creation of a " Centre anti-contrefaçon "

2/ Creation of a data base that will save all the codes generated by the brands

3/ Normalisation of the system

- » System of marking: There will be no monopole on one system
- » System of reading: must be easy to buy and to use by the public authority/ standard reader .
- » System of coding: will be normalised / 2 fixed data et 2 variable data
- » Matriculation number of the brand
- » Matriculation number of the factory / Producer
- » Product number: Alpha numerical suite generated by a conversion matricial .
- » Date of production
- » The computer system that will generate the code will be considered as a " black box" under the control of a security officer that will have a contract with the producer or the brand .

4/ The system must allow the public authority to check the product / Custom Police etc.. and to proceed investigation on fraudulent rings without the demand of the owner of the brand .

The prosecution could be done on an international level

5/ The code will be sent to the central data base and store

6/ The brand controllers, the distributors, the public authority, and the justice will refer to this official data base in order to identify without a doubt a real product from a fake one. This data base will also serve as proof during a legal procedure.


- The first step of this program will be implemented in France / 2006
- The second step of this program will be extended to the European level /2007
- The third step of this program will be international / date to be defined

Relation to Naginels consortium:

Naginels must be normalised right from the start. All of our studies and research must follow this main objective.

This norm is about to be written and will be available end of 2005.

The system of coding must refer to a data base.

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Mr. Delval has given us the name of six companies that are developing special software for the generation of code that will follow the future criteria of the norm. We have decided to get in touch with these companies in September 2005 in order to select the one that will best suit our system.

- | | |
|------------|----------------------|
| » ATT | » Brevets et Patents |
| » ALGORIL | » PROOFTAG |
| » NOTACOPY | » SIGNOPTIC |

We have also discussed these issues in the SB meeting in Epone (September 2005).

In February 2006 we were informed that the Norm Accord was available on the Afnor site.

A copy of this document in this report as an annex Norm AC Z60-100

On June 30, 2006 we had another meeting with Mr. Delval in order to see the evolution of the work and how Naginels could receive a certification of the Norm.

During this meeting we discussed the evolution of the norm AC Z60- 100 and the principles of certification of the technical solutions.


During the meeting Mr. Delval received a telephone call from the presidency of the “ counsel of Europe “ announcing that the Norm Accord ACZ60-100 had been approved for implementation on the European level.

The essential point of this decision is that Europe will harmonize its system of product authentication based on the Norm Accord ACZ60-100.

The drafting of this European norm will start in September 06 and will be achieved in 3 years.

III.7.8.3 Evolution of the norm AC Z60 – 100 in France:

- » Creation of an association with professional federations and the brand owners.
- » The objective of this association is to develop and run the centralized data base .
- » This association will in be in charge of validating and certifying the suppliers with their technical solutions in accordance with the technical specifications with the main principles described in the Norm ACZ60-100.
- » The association will edit a list of technical solutions and related suppliers .
- » The brand owner will have to choose one anti-counterfeiting solution among that list so that his product conforms to the norm.
- » This is why the validation of the Naginels technology by the norm is so important for the future commercial use .

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III.7.8.4 Calendar :

- End of 2006 - creation of the association
- 1st semester 2007 - drafting of the list of the technical solutions with related suppliers .
- End of the 1st semester 2007 - certification of the technical solutions

This association will also be in charge of creating a legal assistance for SME in order to help them defend their business against counterfeiters.

The Naginels consortium will get in touch with the association in order to start the process of homologation of our laser application in the beginning of 2007.


We will get in touch with Mr. Delval for the next meetings in order to contact the association to start the process of certification of the Naginels solution with the Norm Accord ACZ60-

In December 2006 a seminar organized by Afnor will also give information on “ How to built an efficient system against counterfeiters. ”

The seminar will discuss the following issues :

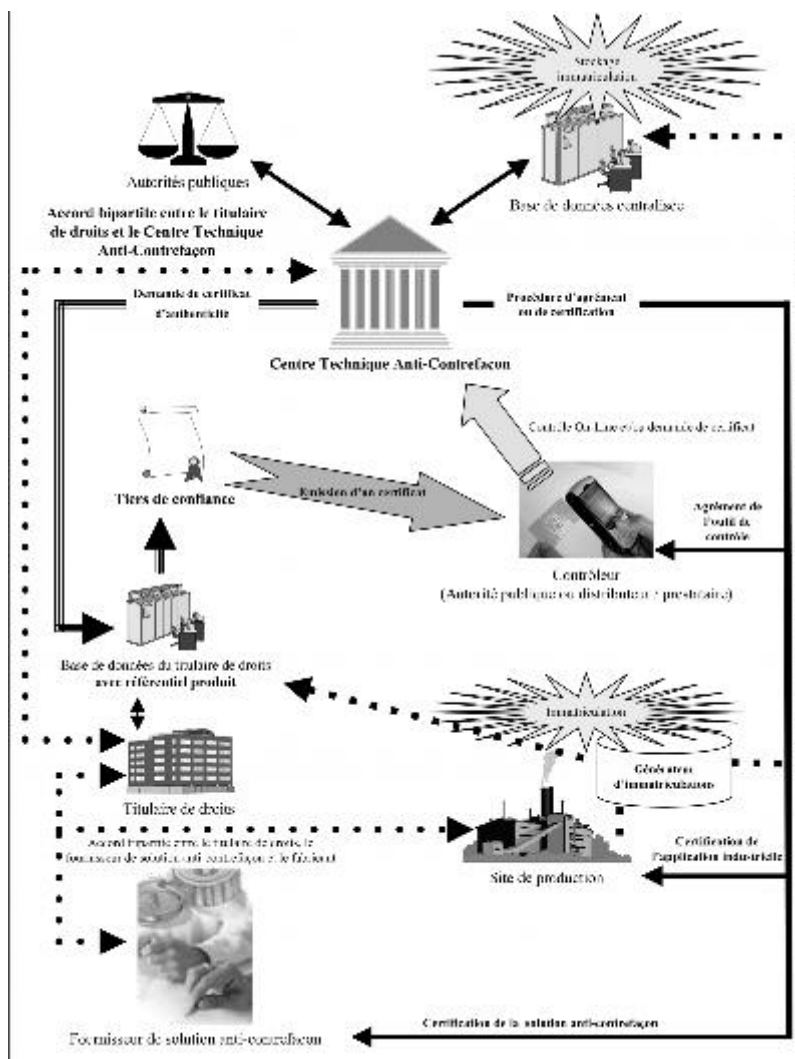
1. New juridical protection . How to use it ?
 - a. New laws
 - b. How to implement them
 - c. Evolution of the laws
2. How to fight counterfeiting ?
 - a. Limits of the European laws
 - b. Economical and technical limits
 - c. The consumer : Victim or accomplice
 - d. Commerce without boundary
3. How to demonstrate a proof of counterfeiting ?
 - a. Objective of the prevention system
 - b. How to authentify
 - c. How to track and trace
 - d. Who will control ? How ?
 - e. How to anticipate the evolution of the international norm ?

This seminar will answer some critical questions and will also give us important information about the ability of the Naginels application to fulfill the criteria of the norm .


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III.7.8.5 Chronology of the work and follow-up for the Naginels Consortium :

1. February 2004: Resolution from the European council for a community system that would allow to fight counterfeiting
2. April 2004: Mr. Nicolas Sarkozy the minister of economy, finance and industry (Minefi) announced the 10 measures for the national action plan against counterfeiting .
3. May 2004: The Minefi put the Imprimerie Nationale in charge of developing the counterfeiting policy .
4. March 2005: The Afnor created the Gelac work group in order to define the majors objectives of a policy for a common authentication and track and trace system on the European level .
5. February 2006: Publication by Afnor of the document : Accord ACZ60- 100
6. April 2006: Presentation of the document ACZ60-100 to the European normalization committee in Bruxelles.
7. June 2006: First meeting with Unifab in order to define the framework of the future “ Groupement de Moyen “.
8. September 2006 to end of 2009: Launching of the European normalization process CEN.



ACCORD philosophy

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III.7.9 WP7.8: Other press releases and seminars


The NAGINELS consortium has decided not to release any scientific publications before the official patent registering (October 2005). Scientific publications would be written and published on the second year of the NAGINELS project. Nevertheless, some articles were written in general press or specialised press by Lasea, TBS and SOLOS.

Lasea has presented the first results in Glasstec 2004 in Dusseldorf, and PALA has presented Naginels in VINEXPO in Bordeaux in June 2005.

KST, TBS and SOLOS have participated to seminars to explain the Naginels technologies or to compare it with other technologies (RFID, labels...).

During the second year, many articles and presentations have been made :


- » 15th November 2005 Conference CRIF (Lasea)
- » 17th November 2005 Conference WTCM (Lasea)
- » November 2005 Press release in packaging magazine « Rassegna dell'imballaggio » (Solos)
- » November Press release in « Pira International » (see the fortnightly electronic newsletter "Brand protection news" on Piranet.com) focusing on the glass market (TBS)
- » 19/01/06 Interview (RTL-TV news 19h) (Lasea)
- » 20/01/06 Article in www.in-pharmatechnologist.com (news stories and data of value to decision-makers in pharmaceutical technology in Europe) (TBS)
- » January 2006 / February 2006 Press paper from "Photoniques" N° 21 January-February 2006 (Amplitude)
- » Février 2006 Norme : AC Z60-100 (AFNOR) Prévention et dissuasion techniques pour la lutte anti-contrefaçon (protection des droits de propriété intellectuelle) – Spécifications d'un cadre générique décrivant les dispositions d'authentification des produits, d'organisation de la traçabilité et de contrôle dédiées à la lutte anti-contrefaçon (Costet)
- » 07/03/06 Article in www.piranet.com (the leading online business resource for the printing, packaging, publishing and paper industries) (TBS)
- » Mai 2006 Article in "The Packaging professional" (TBS)
- » From 17/05/06 to 18/05/06 ESPACE LASER Trade Fair (France) (PALA)

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- » 16/06/06 Demonstration organised in Geneva by M. RUGGIERO from ALL4R. (Presentation of the Naginels codes) (KST / Lasea)
 - » From 26/09/06 to 29/09/06 MICRONORA 2006 International Microtechnology Trade Fair (Besançon, FRANCE) 2 booths (Lasea and PALA)
 - » Sept/Oct 2006 Article in “Product and Image Security” “ONE TO ONE” Magazine Profile Product & Image Security focuses on the information concerning the problems of counterfeiting, ... The magazine features articles related to security materials, security holograms and applications (Product identification, authentication, traceability, brand image protection...) (TBS)
 - » From the 2/10 to 4/10/ 2006 PISEC 06: Barcelona International conference and exhibition for the brand protection, product authentication, document security and RFID industries AWARD for Best Practice in Product and Brand Protection (<http://www.pisec-world.com>) (SOLOS & TBS)
 - » 09/10/06 Conference about the Seventh Framework Programme 2007-2013 (University of Liège) (KST / Lasea)
 - » From the 24/10/06 to the 28/10/06 GLASSTEC International trade fair In Düsseldorf. International exhibition of machines and glass production technics
 - » 10/11/06 Conference in a Pharmaceutical industry in Milano
 - » 07/12/06 Press paper from “Les Echos” (French economic newspaper)
 - § December Press paper from “Verre” VOL.11 N°6
 - §
- (see web site www.naginels.com/news)

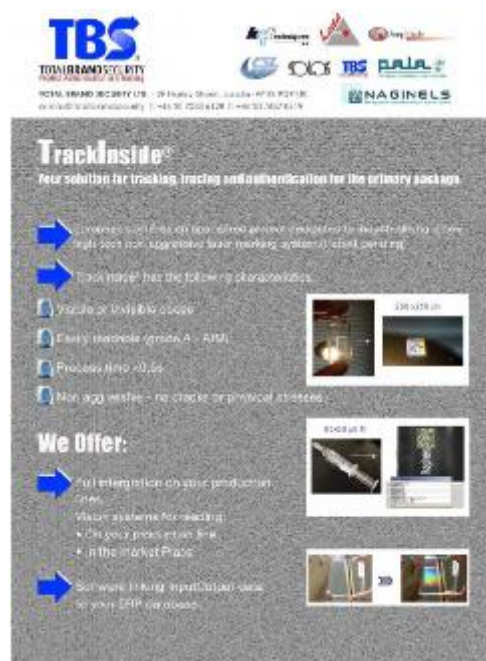
Moreover, all partners have presented the Naginels Technology at different conferences and tradeshowes where they were exhibiting, as Amplitude Systèmes for instance:

- Photonics West 2006, U.S.A.
- CLEO 2006, U.S.A.
- OPTO 2006, France
- Industrial Laser Seminar, Germany
- ICALEO 2006, U.S.A.

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Naginels poster presented on PALA 'S stand in MICRONORA 2006

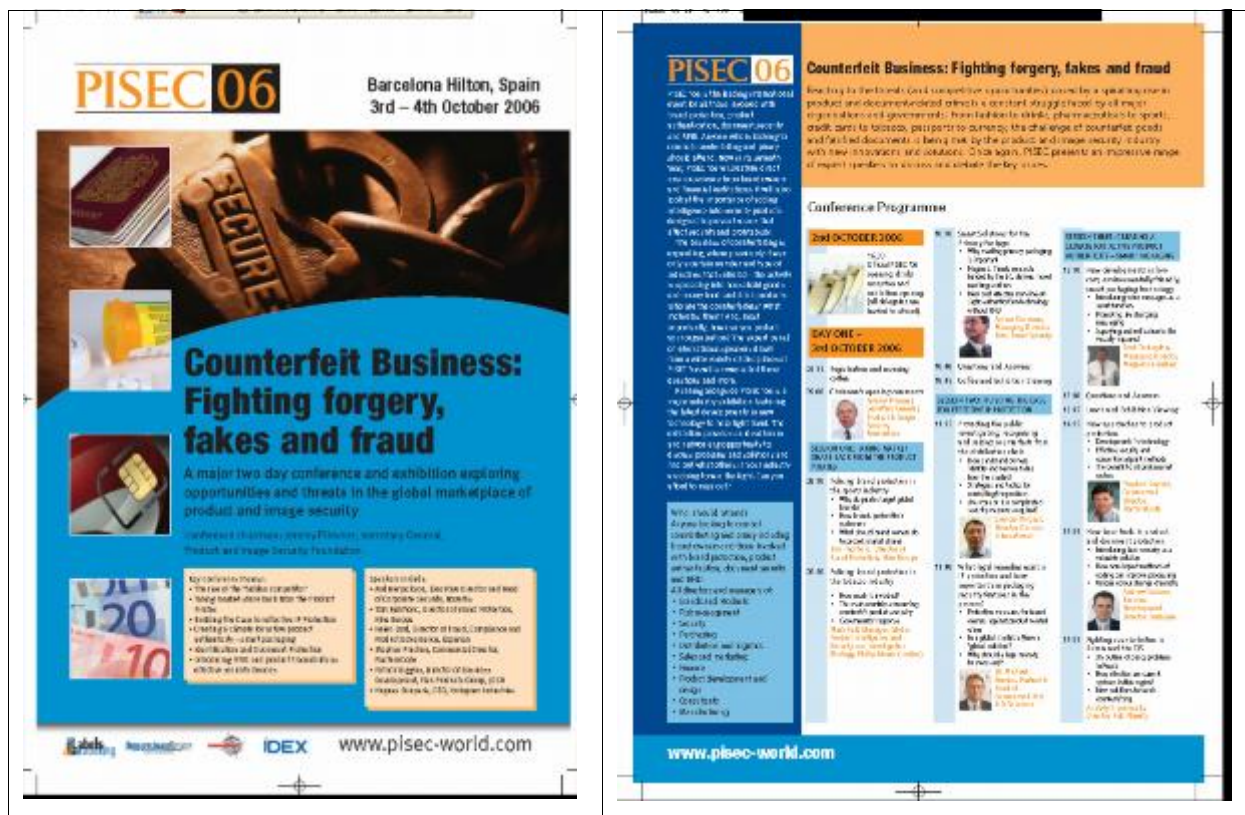


Naginels poster presented on TBS 'S stand in IQPC 2006




PALA's stand in MICRONORA 2006

 NAGINELS Non Aggressive Glass Internal Engraving Laser System	Deliverable No 8.7	Final Activity Report – Section 2	
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Examples of press releases

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III.7.10 Conclusions

- ü The results were very good and a patent has been deposit.
- ü Web site is on-line
- ü Consortium part of the web site is very useful for communication and downloading the different documents
- ü Articles, seminars and presentation have been made by different members of the Consortium (TBS, KST, SOLOS, Amplitude, PALA, LASEA).
- ü End-users (LVMH, Pilkington, and Glaxo-Smith-Kline) have been visited several times and their samples have been proceeded and analysed. Midterm important projects are studied with them.
- ü Naginels is entered in ACCORD program thanks to PALA and COSTET. Specifications of the prototype are studied in order to match the new functionalities required by the new norm.
- ü TBS and SOLOS has presented to Naginels Consortium different opportunities in order to increase the protection of the codes thanks to specific encryption software. Meetings with Kessler Company were organised and they have been invited in some of SB meetings.
- ü Many articles and conferences on the technologies have been made in the second year by all the partners
- ü The first world introduction of the Naginels concept was at the PISEC Barcelona Congress – a world authority on everything related to brand protection. The result of this was winning an award for Naginels also see attachment below.
- ü An industry specific presentation of Naginels was made at the IQPC in London. .
- ü An important presentation of the demonstration unit was made at the Glasstech in Düsseldorf in October 2006. .
- ü The dissemination of the results has been very successful in his now up to the consortium members to follow up with the individual potential customers in order to propagate the market introduction of the Naginels technology.