PROJECT PERIODIC REPORT

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Publishable Summary

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Start date of project: December 1st, 2009 Duration: 36 months

List of Beneficiaries:

Beneficiary Number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1 (coordinator)	LZH Laserzentrum Hannover e.V.	LZH	Germany	1	36
2	Centre Suisse d´Électronique et de Microtechnique SA	CSEM	Switzerland	1	36
3	Sächsisches Textilforschungsinstitut e.V.	STFI	Germany	1	36
4	CIM-mes Projekt sp. z o.o.	CIM-MES	Poland	1	36
5	Trans-Textil GmbH	Trans-Textil	Germany	1	36
6	TTI Technische Textilien International GmbH	TTI	Germany	1	36
7	JUTEC GmbH	JUTEC	Germany	1	36
8	Grado Zero Espace S.r.l.	GZE	Italy	1	36
9	Smartex S.r.l.	Smartex	Italy	1	36
10	TDV Industries	TDV	France	1	36
11	Promat International NV	Promat	Belgium	1	36
12	LASER on demand GmbH	LOD	Germany	1	36
13	ProLas GmbH#	ProLas	Germany	1	12
14	Clean-Lasersysteme GmbH	cleanLASER	Germany	19	36

#: ProLas had to leave the consortium due to insolvency.

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Publishable Summary

The project PROSYS-Laser was dedicated to developing highly innovative “passive” and “active” laser protective clothing for use with hand-held laser processing devices (**HLDs**) and curtains for use with laser machines. The major project objectives were:
a) to open new markets for high performance PPE and its testing, especially dedicated to improving the market situation of the participating SMEs,
b) to sustain the growth of laser technology by providing means for the safe use of innovative HLDs and high-power lasers with high brightness,
c) to minimise health risks for the operators of HLD and automated laser machines,
d) to contribute to standardisation regarding laser PPE and PPE testing procedures.
The approach was to combine innovative laser technology with high performance textile technology. Key developments were:
a) passive functional multilayer technical textiles, providing high laser resistance,
b) active functional multilayer textiles, incorporating sensors which detect laser exposure and, by means of safety control, deactivate the laser beam automatically,
c) test methods and set-ups to qualify passive and active layers and PPE systems.
The work was organised in 8 work packages (WPs) in total. Apart from the management WP, there were seven technical WPs: development of adequate laser-protective multilayer textile systems, taking into account standard PPE requirements, as well as of test methods and set-ups, laser PPE manufacturing including ergonomic aspects, field tests, standardisation issues, and last but not least exploitation and dissemination. The work was done by a consortium of 13 partners from 6 European countries, representing a goal-orientated combination of relevant knowledge and experiences. The partners were 9 small and medium enterprises, 3 research centres, and 1 larger enterprise. The project was coordinated by the Laser Zentrum Hannover e.V., a German non-profit research institution in the field of applied laser technology.

The development of textile-based **passive systems** was one major sub-objective of the project. The systems are composed of materials and layers having specific roles:

- The external layer is able to scatter/diffuse the incident laser radiation to a large extent, having low absorption and ideally low/no transmittance.
- The middle layer is able to absorb the remaining radiation and to spread the incident energy in the textile plane in order to widen the absorption volume.
- The inner layer has optimal thermal properties to minimise heat conduction, allowing a small heat transfer to the skin in order to enable the PPE-using person to remove the irradiated body part upon pain perception.

The passive laser protective textile system was realised using the best combination of materials investigated during the project, taking into account the requirements defined in the **preliminary study** WP and providing, at the same time, laser, fire, and heat protection together with other useful properties like tear and cutting resistance, stain repellence, breathability, antistatic properties, comfort, etc.
More than 150 textiles were selected, partially modified by coating, and investigated with regard to their suitability for the different layers of the passive PPE systems. Low-signal tests for the whole set of materials, yielding the optical properties, as well as irradiation experiments for a selection of promising materials, using high-power diode laser radiation, were performed. Evaluating these experiments, especially the calorimetric measurements, and determining the times between pain perception and

2nd degree burn, according to Stoll and Chianta, as well as the times up to complete layer destruction, several materials were selected for validation in the passive multi-layer systems, which were produced at a laboratory scale and used for the PPE prototypes. The manufacturing of multilayer systems was investigated at a larger scale, too, in order to demonstrate the industrial feasibility of the production process.
As **active systems**, flexible laser curtains and laser PPE with a higher safety level were created. Designing active systems means incorporating sensors into the textile material. Several concepts for a system of coupled sensors were developed and realised for validation with regard to functionality and laser resistivity. Finally, two concepts, based on the irreversible change of the electrical properties of the sensor material, respectively, were selected for the electronics development.
The electronics which interface the smart textiles and sensors, providing signal conditioning, acquisition, on-body pre-processing, local data storage, and communication, was a major part of the active approach. The electronics provide alarms and can ultimately enforce laser shutdown upon defined conditions (irradiation threshold). A wireless signal transmission system (see Fig. 1) was set up and tested, taking into account normative aspects thoroughly. The specifications of this system were defined in terms of system architecture, sensor block diagrams, and safety units, as well as the definition of the safety protocol layer. Finally, prototypes of safety unit and sensor development unit were assembled. Software programming and adaptation with respect to the specific requirements of the active concept were performed. The concept was validated for both sensor types selected.

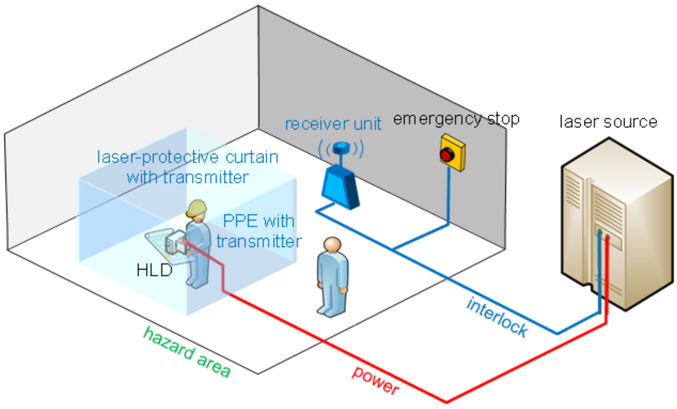

Fig. 1: Automated laser shutdown upon irradiation above a defined threshold.

Preliminary design studies were performed in order to develop basic concepts of the products to be realised: gloves, aprons, trousers, jackets and suits. They helped to choose and to position suitable materials as well as active solutions. The results of these studies were used to manufacture **prototypes of laser-protective clothing and curtains** on a laboratory scale successfully (see Fig. 2). These prototypes were tested in a **field test** series and assessed by means of “evaluation check lists”, and finally optimised especially regarding design, comfort, and ergonomics, based on the acquired feedback of the HLD users involved.


Fig. 2: Passive gloves prototype.

A further important objective of the project was the development of a **testing set-up and corresponding procedures to characterise laser PPE**. The testing set-up is able to measure optical and thermal features of PPE samples. Using the experience of the partners in laser technology, PPE development as well as sensor technology and measurement processes, the testing set-up design was completed (Fig. 3). Accordingly, acquisition of components, performance check of sensing elements, partially using high-power diode laser radiation, as well as integration of subsystems was done. LabVIEW-based software for data gathering from cameras and sensors and electronics for motor control was developed. The modular testing rig considers low-power measurements, providing optical and thermal properties at the laser wavelengths, as well as high-power measurements, taking into account the serious material changes induced by high-power laser radiation and capable to test features of passive and active PPE. Finally, the assembly of a set of 3 testing rigs to be used by different project partners for validation as well as the definition of a procedure to assess the feasibility of laser-protective PPE was performed. The full functionality of the testing rig was shown experimentally in terms of a simplified round-robin test.

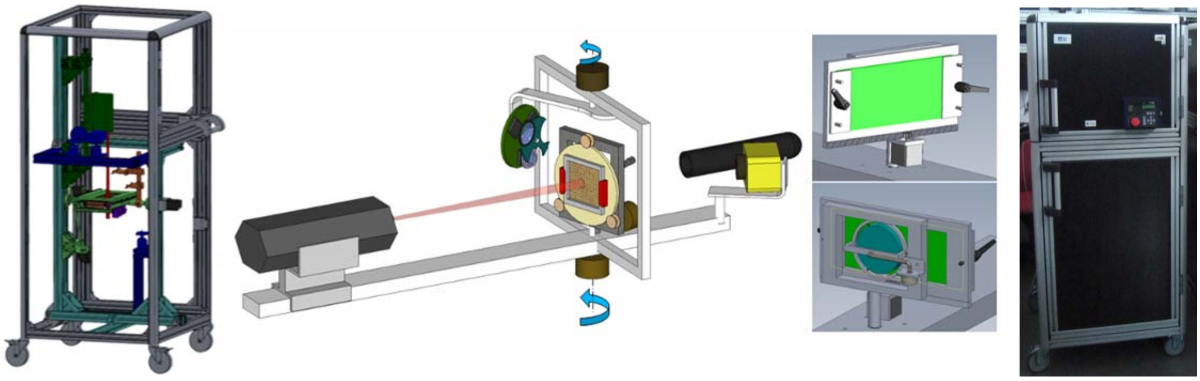

Fig. 3: Conceptual design with selected details and 3D assembly of testing set-up.

As almost no specific clothing for skin protection exists in the field of laser processing up to now, there are no corresponding standards for laser PPE. Only few recommendations are known such as the use of flame retardant working garments.

Not only the PPE prototypes to be developed, but also the testing set-up and the procedures, could be starting points of standardisation activities. Thus, parts of the work were focussed on a **standardisation action plan** concomitantly to the project and the basis for the preparation of a **new work item proposal** (NWIP) for laser PPE and testing procedures. Based on a research on existing regulations in the fields of laser PPE and protective clothing dedicated to fire and welding protection, a strategy how to implement the project results in standards was developed and improved continually. Apart from communicating the relevant information to the **CEN Technical Committees** directly, the project results have been brought in via the national standardisation committees of countries involved in the project consortium of in the Advisory Board. As standardisation is complex and takes quite long, the project duration was not sufficient to obtain the necessary agreements. Moreover, the submission of an NWIP is linked to a defined duration of 36 months for the completion of the standardisation process. Therefore, it was decided to complete the NWIP after the project end, taking into account the final project results, in order to achieve a standard successfully. A detailed **information letter** regarding the testing procedures and laser safety levels proposed for laser-protective textiles was prepared, based on an in-house standard developed mainly by one of the research partners, and members of several national standardisation committees were contacted.

In the frame of the **dissemination and exploitation** WP, various dissemination activities to promote the PROSYS-Laser project and its developments were performed. For instance, different documents suitable to enhance the visibility of the project to the public and therefore to improve the possibilities for exploitation and dissemination of project results (project fact sheet, project flyers, poster) were prepared and distributed at several occasions, e.g. conferences and fairs. Furthermore, a project website (http://ww.prosyslaser.eu), including basic project-related information, was created. Several PROSYS-Laser partners participated in conferences in different European countries in order to present the project to an international audience. For an internal **market survey**, a product questionnaire and end-user interviews were prepared and distributed among the project partners in order to better define plans and actions for each partner involved in the exploitation process.

Two Exploitation Strategy Seminars (ESSs), offered by the EU, were organised. From these seminars, a list of exploitable results providing detailed descriptions, several documents with respect to risks, opportunities and partner relationships, as well as tables for the definition of exploitation claims were generated. The ESS results help to define an enhanced exploitation strategy and to set up contracts that open up the way to collaborative exploitation after the project end. In addition, the ESS results have been implemented into the Plan for the Use and Dissemination of Foreground (PUDF), submitted to the Commission after the project end.

As described, PROSYS-Laser mainly targeted **passive** and **active laser-protective clothing** for use with **HLDs**. The major technical objective was to provide adequate PPE prototypes, which significantly reduce the risk of occupational injuries, and in turn to increase the workers' safety. Finally, this will produce a social win situation, with the preservation of production capabilities and reduced medical costs. A positive image of the innovative HLD technology will be created, which is accepted by the industry as well as by the workers. This development, together with the standardisation of laser PPE and corresponding testing procedures, will support the growth of the overall laser market and therefore also increase the productivity in Europe.

Regarding the HLD market, the project is expected to increase the use of HLDs by more than 50% within a few years after the end of the project, which would probably lead to a break-through for the technology and its large-scale industrial utilisation.

For European textile industry, it is highly important to develop innovative products in order to keep their leadership. Intelligent, knowledge-based materials, developments, and processes need highly qualified personnel. This keeps the industry in Europe. Therefore, especially active laser PPE solutions will strengthen the market position of European SMEs in the world. The knowledge is expected to be transferred to other fields of laser application aside from HLDs, such as protection by **active curtains** during work with **automated laser machines** or use of **lasers in laboratories**.

Active PPE solutions will impact not only the laser processing area. Using smart PPE systems, it will be possible to connect and shut down any potentially dangerous tool in a short time span, thus minimising injuries. An example is the work with electrical arcs. By further development and transfer of these active solutions (textile system, sensor principle, signal transmission) to other PPE applications, it will be possible to gain leadership in the active PPE market. Thus, the project contributes to the **Lead Market Initiative for Europe** in a reliable way.