Deliverable 7.8

Plan for using and disseminating foreground (PUDF)

Project acronym:	SMARTPRO
Project full title:	Lightweight, flexible and smart protective clothing for law enforcement personnel
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Prepared by:	LEITAT
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Dissemination Level		
PU	Public	☐
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	✓
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

Table of Content

1 INTRODUCTION

The Plan for Use and Dissemination of Foreground summarizes the strategy and the concrete actions for the protection, exploitation and dissemination of the results generated by SMARTPRO. It is structured in two parts: the first describing the strategy and actions towards **exploitation** of the project's results and the second presenting the **dissemination** activities undertaken during the project.

As far as ownership, use, dissemination and access rights are concerned the rules set in "Part C: Intellectual property rights, use and dissemination" of the Annex II (General Conditions to the FP7 Model Grant Agreement) have been followed throughout the project and will be followed after the project's end when applicable, i.e.:

- The beneficiaries have reported on the expected use to be made of foreground in the present PUDF. The information is sufficiently detailed to permit the Commission to carry out any related audit.

- All dissemination activities carried out so far are reported in the present PUDF, including sufficient details/references to enable the Commission to trace the activity. With regards to scientific publications related to foreground published before or after the final report, such details/references and an abstract of the publication will be provided to the Commission.

- All dissemination actions concerning foreground include a statement acknowledging the financial support of the European Community and display the EU emblem. The same rule will be applied for any dissemination action related to SMARTPRO's foreground which might be implemented after the end of the project.

Terminology:

- **Use** is defined[1] as the direct or indirect utilisation of foreground in further research activities other than those covered by the project, or for developing, creating and marketing a product or process, or for creating and providing a service. "Direct use" implies that partners utilise the results themselves for commercial applications (e.g. by producing and/or commercialising a new product or by integrating a new process into their manufacturing plant) and/or for further research ("further" with respect to the scope of the project in which the foreground is generated). "Indirect use" implies that partners may allow third parties to exploit the research results through a specific agreement.

- **Dissemination** means the public disclosure of the results by any appropriate means (other than resulting from protecting or exploiting the results), including by scientific publications in any medium;

[1] Source: http://www.ipr-helpdesk.org/documents/ES_UseForegroundFP7_0000006654_00.xml.html

It is stressed that publication and dissemination of foreground has been granted with the approval of the Consortium. In case any patent application related to SMARTPRO's foreground is filed after the project's end the Commission will be notified and provided with sufficient details/references to trace the patent.

Where the foreground is capable of industrial or commercial application and its owner does not protect it, the Union may, with the consent of the beneficiary concerned, assume ownership of that foreground and adopt measures for its adequate and effective protection.

PUDF and Consortium Agreement

The Consortium Agreement is a very important document when it comes to ownership and sharing of knowledge or project results, as it has set out or further defined how the consortium agrees on the use and dissemination of the project results.

The background[2] that was brought into the project will always remain the property of the partner involved. The Consortium Agreement dedicated one section (in Article 7) to define how access to background knowledge will be handled.

In the case of the foreground, i.e. the project results and any IPR that can be attached to them, typically it is owned by the participant that carried out the work from which it resulted. Partners working in the same WP had access rights to all foreground and background needed for the execution of the WP, from all WP Partners, while participants from other WPs enjoyed the same access to foreground and background, when these formed parts of a deliverable or were necessary for the execution of the Task.

[2] "Background" is project-related information and IP rights held by participants prior to the signature of the Grant Agreement.

2 EXPLOITATION

Exploitable results achieved through the implementation of SMARTPRO were identified since early in the project and the list has been continuously updated during its implementation. In this section, the information regarding exploitation is presented per exploitable result, to facilitate usability.

2.1 Key Exploitable Results (KERs)

The following key exploitable results (KERs) were identified with the associated SMARTPRO partners implicated:

- KER1: 3D knitted Kevlar® fabrics (CIMA, LEITAT)
- KER2: Scale type composite for protective applications (LEITAT)
- KER3: Method for graphene growing on carbide particles (FORTH, MIRTEC)
- KER4: Optimized surface treatments for protective textiles (FORTH, MIRTEC, NTT, LEITAT, SOLIANI)
- KER5: Process for self-cleaning functionalization of textile using photocatalytic polymer (NTT)
- KER6: Lightweight and flexible protective panel providing ballistic (Level IIIA) and stab (Level 1) protection (SIAMIDIS, NTT, FORTH)
- KER7: Textile antenna (RWTH, SOLIANI)
- KER8: Textile heart rate sensor (RWTH)
- KER9: New design of modular body armour for riot police and special units (BCB)

2.2 Summary table

Below an overview table summing up the progress made (TRL: Technology Readiness Level) and the impact of each KER. A more detailed description of each KER follows in Section 2.3.

KER	TRL project beginning	TRL project end	Applications of KER	Impact of KER
KER 1: 3D knitted Kevlar® fabrics	TRL 3	TRL 7	1) Spacers for workwear apparel. 2) Spacers for security forces apparel and protective covers for armour vest 3) Anti vandal mattresses 4) Anti vandal seat parts for public transport 5) Industrial fabrics	New product for a new market: E.CIMA will start a production of an aramid spacer for apparel for security forces as a result of knowledge acquired during SMARTPRO project. E.CIMA is able to produce new fabrics for anti vandal mattresses and parts of seats for public transport E.CIMA is able to produce spacers for industry with high cut resistance and tear strength, and spacers for work wear apparel where cutting resistance is a requirement.
KER 2: Scale type composite for protective applications	TRL5	TRL6	1) Individual protection (e.g.: protection vest) 2) Sport protection (e.g.: leg protection for soccer players or use in motorcycle jacket, etc.) 3) Animal protection (e.g.: bite of a dog or other animal)	It is a compact and robust protection system and its geometry allows fitting in the body limb (e.g.: arm or leg). It can be glued on textiles to improve the versatility and integration in the clothes directly.
KER 3: Method for graphene growing on carbide particles	TRL1	TRL4	Synthesis of novel functional materials	Materials for lightweight reinforcement of textile

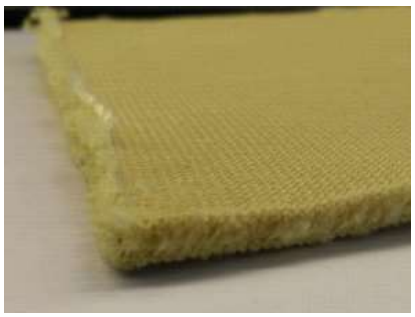
KER	TRL project beginning	TRL project end	Applications of KER	Impact of KER
KER 4: Optimized surface treatments for protective textiles	TRL5	TRL7	1) Lightweight soft body armour 2) Cross-linkable polymers for textile surface treatment	The global body armor market size is expected to reach 5,661 M$ by 2024. Companies investing in NF technologies could benefit from lower production costs. Potential increase of the textile performance at reduced textile weights. Exploit through licensing (fee 4-7%) of the production protocol to company dealing with body armor production. Joint venture with NF equipment producer to promote industrial scale-up. Competitors: DuPont and Toray - Light fiber for ballistic purposes at competitive price
KER 5: Process for self-cleaning functionalization of textile using photocatalytic polymer	TRL6	TRL7-8	1) Leisurewear textile to promote self-cleaning 2) Furniture sectors 3) Photocatalytic filter media - wastewater and air purification	The market for photocatalytic products is expected to grow at a CAGR of 12.6% during the next 2 years, reaching $2.9 billion by 2020. Competitive price for photocatalytic finishing is promising for commercial applications. It is estimated that total revenue could reach up to 1,0 M/€ by 2025. Exploitation: direct sell of the products (expected price 13.5€/kg). Investment for the assembly of semi-industrial reactors or licensing (fee4-5%) for the supply of functional polymer to chemical company. Competitors: titanium dioxide product (Degussa; Nanomaterial Inc.) and photocatalytic SUNDIA Fibre (around 35 €/kg)

KER	TRL project beginning	TRL project end	Applications of KER	Impact of KER
KER 6: Lightweight and flexible protective panel providing ballistic and stab protection	TRL5	TRL7	This KER is directly linked to KER 4 1) Body armours for law enforcement personnel and correctional officers 2) Military body armours 3) Body armours for civilian use	As for KER 4.
KER 7: Textile antenna	TRL3	TRL 5	GPS localization of risk-exposed staff, e.g. at sea, forest or high-terrain	Textile antennas can be integrated in almost any kind of fabric, assuring very good signal reading in any kind of clothing
KER 8: Textile heart rate sensor	TRL3	TRL 4	Hear rate monitoring for risk patients (long-term measurements) and even for fitness sector	Textile electrodes enable high wearing comfort and therefore easy integration in any undergarment for daily use such as for patient monitoring in hospitals or at home
KER 9: New design of modular body armour for riot police and special units	TRL5	TRL7	Body armours with modular and ergonomic design for use by riot police and special units' officers	The key advantage of this KER is that it has been developed according to end-users' requirements and is therefore particularly fitting the needs of specific police units. Further, it is a demonstrator proving the possibility to adapt the design of body armours to specific tasks and operations, maximizing the agility and mobility of the users.

2.3 Description of the KERs

2.3.1 3D knitted Kevlar® fabrics (CIMA, LEITAT)

- *Brief Description*



3D knitted fabric based on Kevlar® yarns made in a warp knitting machine with a separation between faces. This separation is called "spacer" and it corresponds to the fabric thickness. 3D (or spacer) fabrics are textile structures formed by three parts, two faces separated by mean yarns that form columns. The two sides are standard warp knitted fabrics, joined together by the spacer's yarns. These yarns link with the fabrics sides keeping the distance between them. Kevlar® yarns have been used successfully to manufacture such a structure. The technical performances of this type of yarns improve the mechanical properties of the overall structures and allow their potential use in advanced applications.

- *Innovativeness introduced compared to already existing Products*

The innovation included in this KER concerns the use of Kevlar® yarns in the 3D fabric manufacture. While 3D woven fabrics made of Kevlar® have been reported, to our knowledge such high performance yarns have not been used up to now in knitting processing. CIMA has developed a manufacturing process enable for industrial production.

- *Unique Selling Point (competitive advantages)*

There is no similar alternative on the market. CIMA has a unique know-how about manufacturing process, using a modified machinery.

- *Product Market Size*

This development was made for using in protective clothing, in particular in bullet proof and stabbing proof garments. Even if the relevant materials have not been used at the end for SMARTPRO prototypes, there is still a potential for application in this field, as well as in:

- Protective parts for sport garments: motorcycling sector, out road sport cycling sector, motocross.
- Protective wear for military use. Protection against fragments over vital body parts.
- Protective patch in uniforms for security forces. Police, escorts.

- *Legal or normative or ethical requirements*

Legal and normative requirements depend on the final application. For use in protective clothing, the material must fulfil specific requirements according to standards.

- *Competitors*

Manufacturers of high performance 3D woven fabrics.

- *Prospects - customers*

In the case of governmental forces main customer are the public institutions. This is the case for final users such as: Military forces, police forces, etc... In the case of use in sportwear, the customer will be the garment manufacturer.

- *Cost of implementation (before exploitation)*

This product has a low cost of implementation, since the required know-how was obtained during the implementation of SMARTPRO. This know-how is the key of the product. More important cost for exploitation will be preparing a machine for working at industrial width of fabric. At the end of the project the maximum width expected is 40cm.

- *Time to market*

Ready to be introduced on the market, depends on the demand.

- *Adequateness of internal staff*

Cima has the right technical staff for producing this product.

- *External partners to be involved*

A textile warping company is necessary for preparing the Kevlar® warped bean. This company has been identified during the project.

- *Status of IPR: Background*

None.

- *Status of IPR: Foreground*

Partner	Description
LEITAT/CIMA	See Brief Description – Main Know-how

- *Exploitation: Actions foreseen*

Partner	Description
LEITAT	R&D services
CIMA	Direct use for industrial private project

- *Exploitation: sources of financing foreseen after the end of the project*

CIMA may develop the production at its own cost (through direct contract with possible customers).

- *Exploitable result priority map*

Analysis: Each of the potential exploitable results is analysed using a Boston matrix grid. The 'risk grade' (RG) is the product of the impact of any given risk (I) and the probability of that risk occurring (R). On a scale of 1-10, if the risk grade is ≥ 50 then it is assigned as being significant. Subsequently by applying an intervention to that risk, if the potential success of that intervention is ≥ 50% then the risk can be controlled ('ACTION' to 'CONTROL'). If, however, the intervention success is likely to be ≤ 50% then the risk could significantly impact on the success any particular potential exploitable result ('WARNING').

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Disagreement on ownership rules	Negotiate a license agreement.	LEITAT
2	Result aiming at replacing existing and well entrenched technologies	Test with potential customers and review outcomes accordingly.	CIMA
3	Nobody buys the product. Too expensive & Problems at the time of the first sales.	Re-assess production costs. Functional and value chain analysis investigation.	CIMA
4	Know-how risks: know-how copied by competition	Verify alternatives to protect IPR.	CIMA
5	Off time supply of financial means	Plan financial needs to get loans to ease investments and cash-flow problems.	CIMA
6	Nobody buys the product. No compliance to standards.	Adapt to standards	LEITAT

2.3.2 Scale type composites for protective applications (LEITAT)

- *Brief description*

The scale composites are made of a composite of Kevlar® 964C-3140-400 as reinforcement and epoxy resin as the matrix, with thickness of approx. 2 mm. The plate is cut in a hexagonal pattern to generate the scales and provide flexibility to the whole structure. Finally, the plates are stuck with adhesive on textile support.

- *Innovativeness introduced compared to already existing products*

The main innovation shown in the scales composites is the ability to easily reconfigure the geometrical size depending on the body area to be implemented. Depending on the size of the hexagonal plates, different grades of flexibility will be acquired. If a maximum level of flexibility is required, the smaller the hexagons will be; on the other hand, if protection is the main requirement rather than mobility, bigger scales should be formulated.

There are currently similar design approaches in the market regarding the geometrical pattern style; however, none of them considers the possibility to generate different sizes on the patterns implemented in order to achieve different grades of mobility. The companies *TurtleSkin* or *NADG* show the following products:

- ***MFA* (*metal flex armour)*** *by TurtleSkin:* The MFA armour is a combination of different layers of Kevlar® fabric with triangular metal plates on the top distributed in a triangular pattern.
- ***DragonSkin* armour** *by NADG:* This armour is a combination of ceramic plates overlapped in order to achieve a certain grade of mobility.

- *Unique selling point (competitive advantage)*

The main selling point feature would be the geometrical ability of the SMARTPRO scales to be set in different sizes depending on the protection/ mobility requirements of the body area to protect. This feature is an attribute that will be considered as a key value for the product positioning (further developed on point 2.2.5)

- *Product Market Size*

The scale composites could be implemented in a wide range of products where puncture or stabbing protection is required, such as military use or Uniforms for Civil enforcement (Private security, police, correctional officers).

- *Market trends - public acceptance*

Understanding that public acceptance of a product is tightly related to socio-psychological determinants, this point will be answered by forecasting a public acceptance determined by the possible impressions suggested by fish-scale technology.

- **Protection –** Protection against hazards is one of the main concerns of human nature, thus any implementation of the fish-scales to products would be widely accepted and taken into consideration by the fact that it will increase the product safety perception.
- **Customization –** The fact of giving a multiple-choice structure to a same product raises its value by adding different scenarios to be implemented. Moreover, the idea of *manufacturing for customization* has grown and spread over the past years thanks to the appearance of new manufacturing technologies (such as additive manufacturing/ 3D printing) that has helped to materialize this idea.
- **Design inspired in nature –** The product results from a designing process mainly focused on biomimetics, the studding and implementation on how nature provides to animals' protection. Nature is a direct synonym of **functional reliability**, a value very appreciated by markets and costumers, because it ensures its investment.

- *Product positioning*

The SMARTPRO fish-scales can be part of a product line of **protective products,** concisely for **civil enforcement or military use.** Other possible fields of implementation are not discarded.

- *Legal or normative requirements*

For a protective use, this kind of material must fulfil specific requirements. In this case, requirements are cantered on standards. For using these materials in Personal Protective Equipment (PPE) as stabbing proof, the following standards have been identified:

- EU/ISO stab resistant body armour standard
- ISO/DIS 14876-3:1999 Protective clothing - Body armour Part 3 Knife stab resistance
- ISO/DIS 14876-4:1999 Protective clothing - Body armour Part 4 Needle and Spike stab resistance

- NIJ Standard–0115.00 - Stab Resistance of Personal Body Armour

- *Competitors*

The companies ***TurtleSkin*** and ***NADG*** have been identified as competitors, as they use a similar concept.

- *Prospects/Customers*

In the case of governmental forces main customer are the public institutions. This is the case of final users as: Military forces, polices forces, etc...

- *Time to market*

Considering that the elaboration of this module is relatively feasible, the predictions do not exceed more than one year to release the product in the market. Depending on market demand and investments.

- *Adequateness of internal staff*

Given that the composite-material elaboration is mainly a hand-crafted process, a highly prepared team with an advanced knowledge and experience in composite manufacturing will be required. For that reason, it is advisable to involve an external partner to take care of the composite elaboration (further extent of external partner at 2.2.1 point).

- *External Partners to be involved*

The manufacturing processes to obtain the fish-scales are mainly two: fabric infusion to obtain the composites and water cutting to achieve the final pattern geometry. Understanding that the composite elaboration technique is quite complex, the following partners for its manufacturing are suggested:

- For composite elaboration – ***TR Composites*** or ***Airborne***

The post-process to define the plates shape, done with water cut technology, does not require a high level of expertise, for that reason it is advisable for that process a subcontracting.

- *Status of IPR: Background (type and partner owner)*

None.

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
LEITAT	Design development

- *Exploitation: Actions foreseen*

Partner	Description
LEITAT	Publication and licensing

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Disagreement on ownership rules	Negotiate a license agreement.	LEITAT
2	Significant dependency on other technologies.	Identify clearly these technologies and assess their IPRs.	LEITAT
3	Worthless result: performance lower than market needs.	Determine the performance level needed by the market	LEITAT
4	Know-how risks: technology copied by competitors	Verify alternatives to protect Intellectual Capital.	LEITAT
5	Off time supply of financial means.	Plan financial needs to get loans to ease investments and cash-flow problems.	LEITAT
6	Nobody buys the product. Does not comply with the standards.	Ensure compliance with standards	LEITAT

2.3.3 Method for graphene growing on carbide particles (FORTH, MIRTEC)

- *Brief description*

The demonstration of proof-of-concept of SiC particles graphitization using an infrared laser has been explored. The cover graphitic layers were shown to have graphene-like structure. Based on this, the capacity of the Atmospheric Plasma Spraying (APS) technique towards producing similar graphene-coated silicon carbide particles has been investigated. APS will enable the large-scale production of graphene-coated SiC particles.

- *Innovativeness introduced compared to already existing Products*

The technology applied here for the preparation and large-scale production of graphene-coated SiC particles is unique, as no similar method has been reported in scientific publications or patents. The method overcomes severe problems of recent approaches based on wet chemistry to synthesize similar structures. The APS method for production of graphene-coated particles is fast and green as it does not

employ solvents and post-treatment procedures. Further, the quality of the graphene shell is of high quality.

- *Unique Selling Point (competitive advantages)*

The APS method for production of graphene-coated particles is fast and green approach as it does not employ solvents, elaborate procedures and does not require pre- or post-treatment of the materials. The quality of the graphene shell is of high quality. Further, the graphene-coated SiC particles can be directly deposited on a chosen substrate at the desired thickness.

- *Market Trends/Public Acceptance*

The need for nanomaterials with specific uses is increasing globally

- *Product Positioning*

Particles with unique properties. Niche market with expert uses.

- *Competitors*

N/A – completely new product

- *Prospects/Customers*

Potential applications are yet to be defined

- *Cost of Implementation (before Exploitation)*

Cost associated with industrial-scale production yet to be defined.

- *Time to market*

Expected to reach the market around 2020.

- *Status of IPR: Background (type and partner owner)*

The involved partners, MIRTEC and FORTH, have their own background which they provide freely to each other.

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
MIRTEC	Atmospheric Plasma Spraying (APS) technique towards producing graphene-coated silicon carbide particles
FORTH	SiC particles graphitization

- *Exploitation: Actions foreseen*

Partner	Description
MIRTEC	Direct industrial use, patent or publication
FORTH	Licensing, patent or publication

- *Exploitation: Sources of financing foreseen after the end of the project*

R&D Grants

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Disagreement on ownership rules	Negotiate a license agreement.	MIRTEC
2	Worthless result: better technology/methodology exists.	Manage a value analysis.	FORTH
3	Nobody buys the product. Problems at the time of the first sales.	Test with potential customers / users and review outcomes accordingly.	MIRTEC
4	Know- how risks: the patent application is rejected.	Review our claim at the outset and make them stronger.	FORTH
5	Weak exploitation. Inadequate business plan	Involve industrial partners during the testing phase	MIRTEC
6	Influence of laws and regulation on Nanomaterials.	Regulatory overwatch & ensure that nanomaterials are in embedded systems	MIRTEC

2.3.4 Optimized surface treatments for protective textiles (FORTH, MIRTEC, NTT, LEITAT, SOLIANI)

- *Brief Description*

Surface treatments of protective (Kevlar®) fabrics that result in improvement of the protective properties, namely ballistic and/or stab resistance, on an areal density basis. Five different types of coatings have been studied including polymers, SiC, graphene and ceramic.

- *Innovativeness introduced compared to already existing Products*

Higher protective properties (stab and/or ballistic resistance) on an areal density basis compared to existing protective fabrics.

- *Unique Selling Point (competitive advantages)*

Lighter protective fabrics leading to lighter body armours.

- *Product Market Size*

The deployment of the army and law enforcement forces in huge numbers to tackle the increasing threats from the various terrorist organizations is expected to propel demand of the body armour market. Furthermore, the adoption of the advanced variants of body armours by various defence bodies globally has led to an increase in the demand for body armours. As per recent trends, it has been observed that, there has been an increasing focus on the part of various manufacturers to develop and design body armours that are lighter and flexible. Moreover, the manufacturers are using advanced ballistic materials to enhance the survivability. Various military and law enforcement agencies are seeking to replace the older body components with more advanced new solutions. Some of the major players in the market are: Point Blank Enterprises, Inc. (U.S.), BAE Systems, Inc. (U.S.), Australian Defence Apparel Pty Ltd. (Australia), ArmorSource LLC (U.S.), Survitec Group Limited (U.K.), Sarkar Defense Solutions (U.S.), MKU Pvt. Ltd. (India), KDH Defense Systems Inc. (U.S.), Safariland, LLC (U.S.) and Honeywell International Inc. (U.S.) among others.

- *Market Trends/Public Acceptance*

The global body armour and personal protection market was worth US$3.8 billion in 2014 and is expected to increase to US$5.3 billion by 2024, representing a CAGR of 3.18% during the forecast period. The expenditure on body armour and personal protection equipment is expected to be driven by soldier modernization programs, internal security threats, such as terrorism and organized crime, police modernization programs and a general shortage of body armour among several others. In terms of segments, protective clothing and headgear is expected to account for 29% and 27% respectively in the global body armour and personal protection market, followed by soft armour and hard armour.

- *Product Positioning*

The new products are a step ahead on what is already on the market, providing improvements on properties with less weight.

- *Legal or normative or ethical requirements*

Normative requirements exceed existing standards at less weight. There are no ethical constraints on the product or the use of it.

- *Competitors*

Main producers Globally

- Anjani Technoplast
- ArmourSource
- BAE Systems
- Bates Footwear
- Ceradyne
- Combat Clothing Australia Pty Ltd.
- Honeywell
- M Cubed Technologies
- Plasan Sasa Composite Materials
- Point Blank Body Armor Inc
- Sarkar Defence Solutions
- Survitec Group Limited
- *Prospects/Customers*

Security forces personnel and military forces globally.

- *Cost of Implementation (before Exploitation)*

Costs associated with industrial scale implementation of each surface treatment is still to be assessed.

- *Time to market*

2018-2020 depending on the specific treatment.

- *Foreseen Product Price*

Slightly higher than that of existing textiles; however, considering the high efficiency of treated fabrics, there is an economic advantage associated with their use.

- *External Partners to be involved*

Industrial partners to implement (some) treatments in industrial scale.

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
FORTH	treatment with shear thickening fluids and crosslinkable aromatic polymers
MIRTEC	treatment with ceramic coatings
NTT	treatment with SiC or graphene-coated SiC particles
LEITAT	treatment with dilatant polymers
SOLIANI	Coating with graphene

- *Exploitation: Actions foreseen*

Partner	Description
FORTH	Licencing, Services
MIRTEC	Licencing, production
NTT	Licencing
LEITAT	Licencing, Services, production

- *Exploitation: Sources of financing foreseen after the end of the project*

R&D grants for final fine-tuning of the surface treatments. Marketing costs are expected to be covered by partners internal budget.

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Disagreement on ownership rules	Negotiate a license agreement.	MIRTEC
2	Result aiming at replacing existing and well entrenched technologies	Test with potential customers / users and review outcomes accordingly.	FORTH
3	Exploitation disagreement: partners with divergent interests.	Negotiate an exploitation agreement.	LEITAT
4	Know- how risks: a counterfeit cannot be proved.	Attend specialized fairs, to find out about infringing competitors.	FORTH
5	Inadequate communication among partners.	Establish a communication platform with clear rules and apply them strictly.	MIRTEC
6	Influence of laws and regulations.	Ensure compliance to standards	MIRTEC

2.3.5 Process for self-cleaning functionalization of textiles using photocatalytic polymer (NTT)

- *Brief Description*

The photocatalytic compound that is used for the self-cleaning functionalization of the textile is a modified polyether ether keton polymer patented by NTT (WO 2014096999 A1).

- *Innovativeness introduced compared to already existing Products*

Textiles exhibiting photocatalytic activity are mainly produced by integrating photocatalyst (TiO_2) into the textile structure or polymers to be coated onto textile surfaces. The first constraint to be faced is related with the compatibility between the inorganic particles and the organic polymers, so the physicochemical affinity between TiO_2 and (generally speaking) plastics is usually very low. Different methods have been optimised in order to improve the application of photocatalyst into polymers.

1. Spray-coat room temperature curable resins with TiO_2 particles to obtain a photocatalytic external layer. For instance, Smooth-On Crystal Clears 202, a low viscosity urethane resin that cures at room temperature with negligible shrinkage, can be functionalized by spraying with Degussa P25 particles during resin curing.
2. Deposition of titanium dioxide film via sol-gel method. TiO_2 transparent nano-sol was obtained by hydrolysis of titanium tetraisopropoxide in isopropanol, acetylacetone and water. The eventual addition of nitric acid and warming at 80 °C made the hydrolysis complete, modifying the complexing power of the inhibiting ligand (acetylacetone) and providing some thermal energy favouring the structural reorganizations needed for crystallization of TiO_2 nanoparticles.
3. The low affinity between the polymeric substrate and TiO_2 can be moderated by implementing chemical treatments to perform a surface functionalization of the polymeric interface or by choosing a polymer with appropriate functional moieties. For instance, sulfonic groups of a Nafion film were reported to enhance TiO_2 anchoring thanks to the mutual electrostatic interaction. Thus, the resulting thin film photocatalyst showed stable performance during long-term operation, without TiO_2 leaching from the polymer surface.

4. TiO_2 can also be bound on inert thin polymer films without charged groups (such as sulfonic, carboxylic or phosphonic) able to interact electrostatically with the TiO_2.Thus, heating Tedlars, Parylene or low-density polyethylene films, inside an alcoholic suspension of TiO_2 particles, introduces oxidative binding sites on the polymer surface that properly anchor TiO_2.

In addition to the common polymer coatings or laminates, there are special chemical agents that can be added to the polymer or as topcoats to achieve various special properties when combined with the fabric. There are for example photo-luminescent chemicals, color changing dyes and UV absorbing agents just to name a few. These new materials add to the vast variety of properties that can be achieved with composite fabric structure. These possibilities could also bring more substance and functionality to architectures. Some of the desired properties of modified textiles are intelligent textiles (fibres with functional properties with the capacity of response to environment), chromic materials which react by changing, erasing or radiating colour, conductive materials or electrotextiles, fibres able to produce electrical energy, materials with phase change as for example microcapsules of PCMs, fibres with shape memory and self-cleaning due to the photocatalyst occurred in the surface of the fibre. Some photocatalytic fibres available in the market are listed below:

1. **Self-cleaning keratin fibres** can be realized following a bottom-up nanotechnology approach in which anatase nanocrystals of TiO_2 are prepared and carefully applied to the fibres via a low temperature sol-gel process to maintain their intrinsic properties, which would be drastically affected by warming at high temperature. The sol-gel process consists of a procedure similar to the previously described ones, based on titanium tetraisopropoxide hydrolysis.
2. **Sundia Fibre-Omi Kenshi** Sundia is a functional photocatalytic rayon fibre impregnated with titanium oxide particles that has been supplying denim woven of an intimate blend yarn of cotton and Sundia rayon since approximately 2006. Sundia functional fibre are used for example in the patent Boots US 8099881 B2, which abstract say that are using this fibre to provide boots which have hygienic and health advantages such as the ability to effectively deodorize the inside of the boots. To achieve these properties the patent recommend introduce some substance as bicho charcoal, a photocatalyst as titanium oxide, sulphur, germanium or zirconium ore have been interwoven.
3. Selfclear acrylic yarns – Exlan: a photo-catalytic spun acrylic yarn has been developed. Product's main uses are for fashion apparel, sportswear, uniforms, bedding linen, and carpets. Since titanium oxide is kneaded into acrylic fibre as a photo-catalyst, the acrylic fibre has self-cleaning functions.
4. Shineup – Kurakay: Polyester based yarns embedded with Titanium dioxide assuring photocatalytic properties.

- *Unique Selling Point (competitive advantage)*

Consortium owns the right to exploit these products for the production of textile products and in particular for the production of photocatalytic yarns. The main advantage is that in contrast to nanoparticles, where specific activities dealing with handling and health safety must be considered, in the case of photocatalytic properties no such issues are raised.

- *Product Market Size*

It is very broad since it can be applied in many different sectors, included but not limited to the carpet industry, building sector and filtration

- *Market Trends/Public Acceptance*

The market for photocatalytic materials is expected to grow from a volume of $800 million to $2.5 billion by 2015, as proposed in the market report ‘Photocatalysts: Technologies and Global Markets’

by BCC Research (2010). BCC also analysed that the photocatalytic products for the construction sector currently accounts for the largest share of the market and it will face the largest increase in the near future. One of the main technology drivers for further expansion of photocatalytic products market is the improvement of antibacterial efficiency that is expected to lead the implementation of these materials in the market. In regards to acceptance, this is a safer material that could improve safety and thus can be successfully commercialized

- *Product Positioning*

Photocatalytic materials for production of photoactive yarns or plastics.

- *Legal or normative or ethical requirements*

No specific standard or regulation

- *Competitors*

Main competitors for textile products are listed above (in the section regarding innovativeness introduced compared to already existing products).

- *Prospects/Customers*

Final customers are very broad since the material can be applied in different technical textile applications.

- *Time to market*

Considering that the elaboration of this module is relatively feasible, the predictions do not exceed more than one year to release the product in the market after the project will be concluded.

- *External Partners to be involved*

Large manufacturer of formulation must be involved for commercialisation

- *Status of IPR: Background (type and partner owner)*

NTT WO 2014096999 A1

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
NTT	Production of photocatalytic material and formulation

- *Exploitation: Actions foreseen*

Partner	Description
NTT	L - Royalties for process/product commercialization

- *Exploitation: Sources of financing foreseen after the end of the project*

R&D funds for products development. Companies to invest in the scale-up.

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Industrialization at risk: no manufacturer for the exploitable result.	Negotiate a license agreement.	NTT
2	Result aiming at replacing existing and well entrenched technologies	Test with potential customers / users and review outcomes accordingly.	NTT
3	Nobody buys the product. Too expensive.	Re-assess production costs and make functional and value chain analysis investigation.	NTT
4	Know- how risks: a counterfeit cannot be proved.	Attend specialized fairs, to find out about infringing competitors.	NTT
5	Off time supply of financial means.	Plan financial needs & potential funding scheme to ensure industrial scale development and then get loans to ease investments and cash-flow problems.	NTT
6	Influence of laws and regulations.	Ensure compliance with standard	NTT

2.3.6 Lightweight and flexible protective panel providing ballistic and stab-protection (SIAMIDIS, NTT, FORTH)

- *Brief Description*

Lightweight protective panel exhibiting Level IIIA ballistic and Level 1 stab resistance.

- *Innovativeness introduced compared to already existing products*

Higher protective properties (stab and ballistic resistance) on an areal density basis compared to the panel consisting of untreated protective fabrics.

- *Unique Selling Point (competitive advantages)*

Lightweight, combination of ballistic and stab resistance.

- *Product Market Size*

It has been observed that, there has been an increasing focus on the part of various manufacturers to develop and design body armours that are lighter and flexible. Moreover, the manufacturers are using advanced ballistic materials to enhance the survivability. Various military and law enforcement agencies are seeking to replace the older body components with more advanced new solutions. Some of the major players in the market are: Point Blank Enterprises, Inc. (U.S.), BAE Systems, Inc. (U.S.), Australian Defence Apparel Pty Ltd. (Australia), ArmorSource LLC (U.S.), Survitec Group Limited (U.K.), Sarkar Defense Solutions (U.S.), MKU Pvt. Ltd. (India), KDH Defense Systems Inc. (U.S.), Safariland, LLC (U.S.) and Honeywell International Inc. (U.S.) among others.

- *Market Trends/Public Acceptance*

The global body armour and personal protection market is expected to be worth US$3.8 billion in 2014 and to increase to US$5.3 billion by 2024, representing a CAGR of 3.18% during the forecast period.
The expenditure on body armour and personal protection equipment is expected to be driven by soldier modernization programs, internal security threats, such as terrorism and organized crime, police modernization programs and a general shortage of body armour among several others.
In terms of segments, protective clothing and headgear is expected to account for 29% and 27% respectively in the global body armour and personal protection market, followed by soft armour and hard armour.

- *Product Positioning*

The new product is a step ahead on what is already on the market, providing improvements on properties with less weight. Target technical performances of protective panels realised by using treated fabrics have been achieved according to end-user expectations:

- Ballistic performances: IIIA
- Stab performances: Level I
- Weight: < 5.8 kg/m^2

- *Legal or normative or ethical requirements*

Normative requirements that have been used to characterise the protective panels are NIJ standards which are widely known and accepted by police agencies throughout the world. Thus, the NIJ standard provides the performance level for protective vests, according to the following features:

- Stab resistant performances have been characterized according to the NIJ 0115.0 standard.

Protection level	1	2	3
E1 Strike Energy	24 J Penetration < 7 mm	33 J Penetration < 7 mm	43 J Penetration < 7 mm
E2 Over Strike Energy	36 J Penetration<20mm	50 J Penetration<20mm	65 J Penetration<20mm

- Ballistic resistance was characterized according to NIJ 0104.4 standard.

Protection level	Test Bullet	Bullet weight	Reference velocity
I	.22 caliber LR LRN .380 ACP FMJ RN	2.6 g. 40 gr. 62 g. 95 gr.	329 m/s 329 m/s 322 m/s 322 m/s
IIA	.9 mm FMJ RN 40 S&W FMJ	8.0 g. 124gr. 11.7 g. 180 gr.	341 m/s 341 m/s 322 m/s 322 m/s
II	.9 mm FMJ RN 357 Magnum JSP	10.2 g. 40 gr. 10.2 g. 158 gr.	367 m/s 367 m/s 436 m/s 436 m/s
IIIA	.9 mm FMJ RN 44 Magnum SJHP	8.2 g. 124 gr. 15.6 g. 240 gr.	436 m/s 436 m/s 436 m/s 436 m/s
III	7.62 mm NATO FMJ	9.6 g. 148 gr..	847 m/s 847 m/s
IV	.30 caliber M2 AP	10.8 g. 166 gr..	878 m/s 878 m/s

- *Competitors*

Main producers globally include Anjani Technoplast, ArmourSource, BAE Systems, Ceradyne, Combat Clothing Australia Pty Ltd., Honeywell, M Cubed Technologies, Plasan Sasa Composite Materials, Point Blank Body Armor Inc, Sarkar Defence Solutions, Survitec Group Limited

- *Prospects/Customers*

Law enforcement personnel and military forces globally.

- *Time to market*

2020 by two years after the end of the project. The buffer time is requested to start negotiation with companies that are willing to invest in the technology/scale-up trials requested for a succesfull implementation of the solutions identified within the project.

- *Foreseen Product Price*

It is expected to be slightly more than existing products

- *Status of IPR: Background (type and partner owner)*

Each partner has their own background which they provide freely to the consortium

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
FORTH	treatment with crosslinkable aromatic polymers
NTT	treatment with SiC or graphene-coated SiC particles
SIAMIDIS	Assembly of the panel

- *Exploitation: Actions foreseen*

Partner	Description
FORTH	Licencing, Services
NTT	Licencing
SIAMIDIS	Direct Industrial Use

- *Exploitation: Team and Partner/s involved expectations*

FORTH	Enter new markets
NTT	Enter new markets
SIAMIDIS	Increase turnover and profitability

- *Exploitation: Sources of financing foreseen after the end of the project*

Marketing costs will be covered by partners' internal budget. Scale-up costs will be charged by companies that are willing to implement the new technologies and products at industrial scale. Partner will provide technical supports.

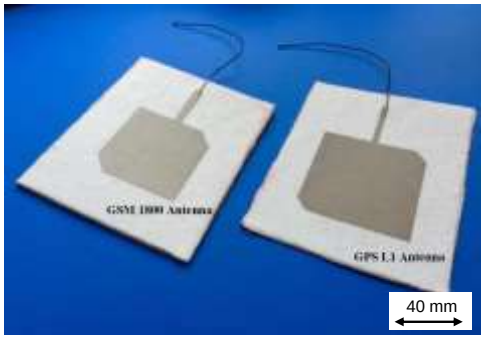
- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Scope and type of potential intervention	Lead Partner
1	Disagreement on ownership rules	Negotiate a license agreement	SIAMIDIS
2	Result aiming at replacing existing and well entrenched technologies	Determine the performance level needed by the market and test with potential users	NTT
3	Nobody buys the product. Too expensive.	Re-assess production costs and make functional and value chain analysis investigation. Value costs versus benefits with potential users	SIAMIDIS
4	Know- how risks	Verify alternatives to protect Intellectual Capital. Apply for trademark	SIAMIDIS
5	Off time supply of financial means.	Business plan	SIAMIDIS
6	Influence of laws and regulations	Ensure standards compliance	SIAMIDIS

2.3.7 Textile antennas (RWTH/ITA)

- *Brief Description*



Textile antennas were developed which can be used for geo-localisation using the GNSS (Global Navigation Satellite System). The textile antennas may be integrated into the body armour itself. The data that is measured e.g. by the heart rate sensor must be transferred from the tight-fitting undergarment worn underneath the body armour to the data processing unit within the armour itself by data transmission via Body Area Network (BAN). Via, an also developed, textile GSM antenna, the data are sent to a remote location such as an operation centre. This type of data includes positioning data received by the GNSS module as well as sensor data from the sensors of the body armour.

- *Innovativeness introduced compared to already existing Products*

There are several approaches for textile antennas that have been investigated and tested in the past. The integration into a body amour has not been realized so far. As the design and simulation of an antenna is very sensitive concerning materials, size and geometry a specific solution for the positioning and integration of the antenna has to be found. This has been realized within SmartPro. Furthermore, the comparison of textile antenna to other GPS-antennas and receivers in field test has not been done before.

- *Unique Selling Point (competitive advantage)*

Textile antennas offer several advantages in comparison to conventional, rigid antennas. Since the size of antennas is directly linked to the frequency of the antenna, antennas are usually the biggest component within the electronics and therefore often the most difficult components to integrate into clothing without causing discomfort to the wearer. Textile antennas overcome these problems by being flexible and easy to integrate into clothing. One of the main advantages of the integration of the geolocalisation system into clothing as opposed to the integration into handheld devices such as radio equipment is that these integrated systems cannot be forgotten or lost during operation.
Conventional rigid patch antennas are especially problematic for the use as GNSS antennas: In order to provide good reception of the signals transmitted by the satellites, the antenna should be placed in a position with good view to the sky. In clothing, this includes positions on the shoulder and the upper back. However, these regions are also rather sensitive areas and rigid parts in these areas results in discomfort for the wearer. This is where textile GNSS antennas show their big strength: they can be integrated in regions with good reception without impairing the wearer's comfort. Additionally they are larger than miniaturized rigid ceramic antennas, which results in a better efficiency. Also, due to the bigger size, textile antennas can be produced as highly adapted, circularly polarized antennas. The circular polarisation of a GNSS antenna offers several advantages.

- *Product Market Size*

This development is made for use in protective clothing for a long-term monitoring of the wearer. Other possible applications are:

- Integration in underwear for elderly people, especially people suffering from dementia diseases
- Integration in outdoor clothing for athletes e.g. during mountain climbing

- Integration in a horse riders protective vest and/or in a saddlecloth of a horse for geolocalisation of rider and horse in case of emergency

- *Market Trends/Public Acceptance*

The feedback from the involved end-users is that the integration of the textile antenna is not a top priority. Furthermore, the textile antennas compete with conventional mobile phones, radios or components of them. The inconspicuousness of the textile antenna integrated into armour can be a good reason for using them as well as the security of being always available.

- *Legal or normative or ethical requirements*

Depending on the type of antenna specific frequencies have to be addressed. The operating systems Terrestrial Trunked Radio (TETRA) which is the standard operating system used by the Emergency Services within Europe, requires a specific licence and currently no partner with appropriate licence for development and testing is part of the SmartPro consortium. It has to be evaluated in a use case scenario if there is a security issue when using GSM standard for the data transfer.

- *Prospects/Customers*

Especially the geolocalisation should be a quite interesting feature for body armour of law enforcement personnel. Although the first feedback of the end-users results in moderate interest for the integration, there might be a market for the integration into body armours for special task forces or military use. Furthermore, transfers of the know-how to applications like localization of dementia patients or for sports activities is feasible.

- *Cost of Implementation (before Exploitation)*

This product has a low cost of implementation. After the project know-how has been obtained. This know-how is the key of the product.

- *Time to market*

This depends on the electronic integration and the use case model of data communication. Currently we think of one or two years.

- *Adequateness of internal staff*

ITA has the technical staff for producing the textile antennas into body armour. For the high-frequency competence ITA has a very strong cooperation with the Institute of High Frequency Technology of RWTH Aachen University, which can realize all measurements and simulations. In case of quite easy communication protocols (e.g. the transfer of positioning data) the electronic part and software realization can be realized with internal staff. If more complex and a greater amount of data are needed, ITA will look for commercially available systems or components.

- *External Partners to be involved*

A partner for the electronics and the software needs to be involved.

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
ITA	See Brief Description – Main Know-how

- *Exploitation: Actions foreseen*

Partner	Description
ITA	Know-how / R&D services

- *Exploitation: Sources of financing foreseen after the end of the project*

ITA will look for customers from different applications that are interested in the know-how.

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Industrialization at risk: no manufacturer for the exploitable result	Assess potential alternative market and contact potential manufacturer	ITA
2	Worthless result: earlier patent exists	Seek legal advice against liabilities	ITA
3	Exploitation disagreement: partners with divergent interests	Test with potential alternative customers / users and review outcomes accordingly	ITA
4	Know- how risks: the patent application is rejected	Review your claim at the outset and make them stronger.	ITA
5	Multiple changes to original objectives.	Adapt business plan	ITA
6	Social acceptance	Ensure the adequate target and compliance with standard	ITA

2.3.8 Textile heart rate sensor (RWTH/ITA)

- *Brief Description*

Textile electrodes for the monitoring of heart rate have been developed. The most important requirement for these dry electrodes is functionality. Therefore, a specific structure of the electrode surface has been developed via moss embroidery to increase usability. Moss embroidery is a special way of embroidery which leads to a moss-like surface, which provides a good contact of the electrode to the skin. Furthermore, the moss-like surface of the electrodes feels comfortable and soft even when obtained by using silver-coated polyamide fibres.

- *Innovativeness introduced compared to already existing Products/Services*

There are several textile electrodes that have been investigated and tested in the past. By using the moss embroidery, a dry electrode is realized which provides good skin contact, feels comfortable and shows good washability. All these factors are important for the use case of a long term monitoring of law enforcement personnel. The electrodes must be embroidered on stretchable substrates to realize a good fit to the wearer.

- *Unique Selling Point (competitive advantages)*

The main advantages of the realized heart rate sensor are the excellent properties of the electrodes and the quite good established production technology. In general, the moss embroidery as a textile production technology is well established. The use of electro-conductive yarn in this context is new and the machine parameters and handling has to be adapted. By this, a production of electrodes can be realized in very flexible and productive ways.

- *Product/Service Market Size*

This development is made for using in protective clothing for a long-term monitoring of the wearer. Other possible applications are:

- Integration in underwear for elderly people or any other people who needs to be monitored concerning their vital parameters (military; jobs where critical health situation threaten other people)
- Integration in fitness suits to increase the effectiveness of fitness training

- *Market Trends/Public Acceptance*

The feedback from the involved end-users is that such a heart rate sensor is not a top priority. The protection functionalities and the weight reduction to improve the comfort of the armour have much more importance to the users. Therefore, the right market might not be market of law enforcement personnel protective armour but rather the market of medical or fitness applications.

- *Legal or normative or ethical requirements*

If the technology will be transferred to medical applications further investigations are necessary.

- *Prospects/Customers*

The potential for the textile antennas for protective clothing is given. Nevertheless, the end-users involved in the SmartPro consortium are not delighted with the smart systems yet because of other more substantial needs.
Other target groups are elderly people, e.g. suffering from cardiovascular weaknesses or athletics who wants to increase the effectiveness of their fitness training due to the monitoring of their vital parameters. Furthermore, the textile electrodes could be used for monitoring of high-performance animals, e.g. race horses.

- *Cost of Implementation (before Exploitation)*

This product has low cost of implementation. After the project, know-how has been obtained. This know-how is the key of the product. More important cost for exploitation will be preparing a machine for working at industrial width of fabric.

- *Time to market*

This depends on the electronic integration and the use case model of data communication. Currently, at least two years are expected with regards to the certification process.

- *Foreseen Product/Service Price*

The product price depends on the context of use of the textile electrodes. If they are used as conventional heart-rate or ECG monitoring systems by simple replacement of the adhesive electrodes or if complete new systems have to be build. In the latter, further partners have to be involved.

- *Adequateness of internal staff*

Currently, ITA has the right technical staff for the production of textile electrodes integrated in underwear shirt. For the electronic part, we are looking for commercially available systems or components.

- *External Partners to be involved*

A partner for the electronics and the software needs to be involved.

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
ITA	See Brief Description – Main Know-how

- *Exploitation: Actions foreseen*

Partner	Description
ITA	Know-how / R&D services

- *Exploitation: Sources of financing foreseen after the end of the project*

ITA will look for customers that are interested in the know-how. From our experience, the producer of conventional heart-rate or ECG monitoring systems become more and more aware of textile electrodes and are interested in new products. That means there is a good chance to find external partner to follow-up the developments.

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Potential intervention	Partner
1	Industrialization at risk: no manufacturer for the exploitable result	Assess potential alternative market and contact potential manufacturer	ITA
2	Worthless result: earlier patent exists	Seek legal advice against liabilities	ITA
3	Exploitation disagreement: partners with divergent interests	Test with potential alternative customers / users and review outcomes accordingly	ITA
4	Know- how risks: the patent application is rejected	Review your claim at the outset and make them stronger.	ITA
5	Multiple changes to original objectives.	Adapt business plan prior to the expiration of grant.	ITA
6	Social acceptance	Ensure the adequate target and compliance with standard	ITA

2.3.8 New design of body armour (BCB)


Front

- *Brief Description*

Modular design of body armour for riot police and special units' officers, adapted specifically to the end users' requirements.

- *Innovativeness introduced compared to already existing Products*

Design developed in close collaboration with end-users, adapted to their requirements in accordance with the tasks performed.

- *Unique Selling Point (competitive advantages)*

Modularity and ergonomics

- *Product Market Size*

The expenditure on body armour and personal protection equipment is expected to be driven by soldier modernization programs, internal security threats, such as terrorism and organized crime, police modernization programs and a general shortage of body armour among several others.

- *Product Positioning*

Improved wear ability and comfort

- *Prospects/Customers*

Law enforcement personnel globally.

- *Time to market*

2018 just after the end of the project.

- *Foreseen Product Price*

It is expected to be competitive compared to existing products although having increased comfortability.

- *External Partners to be involved*

None

- *Status of IPR: Foreground (type and partner owner)*

Partner	Description
BCB	New design of body armour adapted to end users' requirements

- *Exploitation: Actions foreseen*

Partner	Description
BCB	Direct Industrial Use

- *Exploitation: Team and Partner/s involved expectations*

BCB	Increase turnover

- *Exploitation: Sources of financing foreseen after the end of the project*

Marketing costs are expected to be the only necessary after the project end.

- *Exploitable Result Priority Map*

The risks outlined in the table below are those recognised at the outset of the project, where potential contingencies have been identified.

	Major Risks	Scope and type of potential intervention	Lead Partner
1	Disagreement on ownership rules	Negotiate a license agreement	BCB
2	Result aiming at replacing existing and well entrenched technologies	Test with potential customers / users and review outcomes accordingly.	BCB
3	Nobody buys the product. Too expensive.	Re-assess production costs and make functional and value chain analysis investigation.	BCB
4	Know- how risks: it is easy to counterfeit	Apply for trademark	BCB
5	Off time supply of financial means.	Plan financial needs	BCB

3 DISSEMINATION

Dissemination of SMARTPRO's results was done during the implementation of the project through different channels and in different manners, including: the project's website, newsletters, dedicated workshops with end-users' representatives, the Final Conference, scientific publications and presentations in conferences and fairs. More information is given below.

3.1 Website

SMARTPRO's website was developed early during the project. It includes general information about the project and its research activities. In addition, project partners are listed with a short descriptive paragraph and links to their own websites. Then, a precise time table can be found on a separate page. Of course, a contact page has been added for media, partnership or any inquiries. An intranet has been also set up for the consortium to share and work easily on project documents. Furthermore, an events section is available containing all recent news of the project. This includes meetings, workshops, etc. Last, a section with the project's newsletters has been created.

The website has basically two objectives: to inform visitors and function as a working tool for the consortium. The first objective is directed towards any visitor, might it be a person interested in the topic or a researcher curious about the project. Therefore, general (home pages) and specific (project page) information has been included in the website. The second objective is rather focused on the intranet were partners can exchange working documents such as deliverables, meetings agendas, etc. It is worth mentioning that the website has been created with a responsive technology so that it can be used in screens of all sizes (smartphones, tablets, PCs, laptops etc.) without adjustments.

3.2 Newsletters

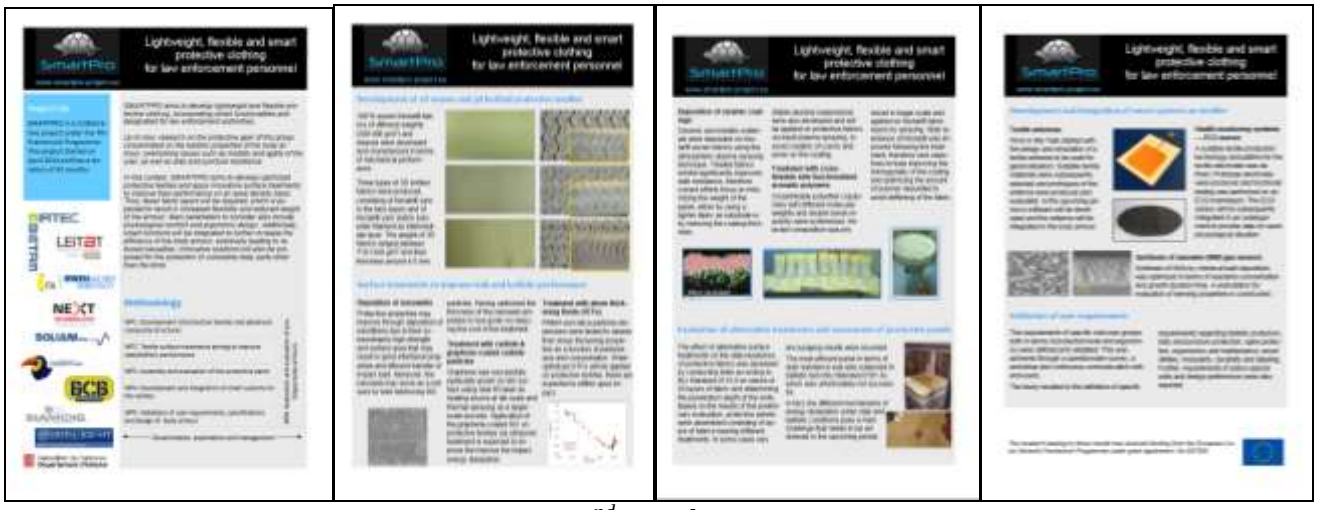
Four newsletters have been issued since the beginning of the project.

The **first newsletter** was published in April 2014 (at the kick-off of the project) and contains basic information about SMARTPRO, its goals, but also more specific about the technologies used for the development of protective armours.

The **second newsletter**, published in July 2015, is more technical than the first one and presents technological project developments. This includes the development of 2D woven and 3D knitted

protective textiles, surface treatments to improve stab and ballistic performance, the evaluation of alternative treatments and assessment of protective panels and the development of smart systems. All sections are illustrated with images for ease of understanding.

1st newsletter



2nd newsletter

The **third newsletter**, published in September 2016, contained updated information on the development and testing of the protective panels, the smart functionalities and the design of the body armours.

3rd newsletter

Finally, the **fourth newsletter**, published at the end of the project includes an overview of the results and main conclusions reached.

4th newsletter (first pages)

3.3 Workshops with end-users' representatives

On the 14th of October 2014, the **first workshop** of the project took place in Barcelona. During this day, the consortium gathered feedback from end users. For that sake, more than thirty people met, from project partners to end users of different law enforcement bodies including Mossos d' Esquadra from Catalonia and experts from Home Office in the UK and the Police Service of Northern Ireland (PSNI). These two last organisations were invited to share needs and experience about protective clothing and body armour. This was a great way to disseminate with potential users about the first project results and get input from them regarding their requirements. After a work in group sessions and an open

discussion, the scientific experts from the SMARTPRO consortium got interesting feedback from the end users, which was helpful to better align the objectives of the project with the needs of the law enforcement units and to plan the next steps of the project.

A **second workshop** took place on the 20th of June 2017 in Barcelona hosted by Mossos d'Esquadra from the Internal Department of the Generalitat of Catalonia. During this event, key partners presented the results to the police forces including the prototypes of the body armours. It was an important moment for the finalisation of the prototypes and the kick-off of their subjective evaluation by end users.

3.4 Final Conference

The Final Conference of SMARTPRO took place on the 21st of June 2017 in Barcelona. In total, around 30 persons attended the event, including delegates of the local municipal police forces, i.e. Terrassa. Also, persons from companies producing personnel protective equipment.

First, the consortium presented the innovations made during these years of research in the field of protective equipment and materials. This included the new fabrics and ways of assuring that the equipment truly protects the body against bullets and stabs. Then, they presented the smart features of the body armour and finally the prototypes, which most of the participants were waiting for. The event lasted an entire morning with time allocated for questions and answers as well as networking.

This event was crucial as the stakeholders had the opportunity to get directly in touch with the consortium and enquire about further developments and market entry possibilities.

3.5 Scientific publications – Participation/presentations in conferences and fairs

The scientific publications and presentations in conferences and fairs aiming to disseminate the project and its results are listed in the following Tables.

Scientific Publications

	Title	Author(s)	ISBN	Publisher	Year of publication	Pages
1	Smart Protective Clothing for Law Enforcement Personnel	Meike Reiffenrath, Melanie Hoerr, Thomas Gries, Stefan Jockenhoevel	10.7250/mstct.2014.010	Material Science. Textile and Clothing Technology	2014	64-68
2	Laser processing of SiC: From graphene-coated SiC particles to 3D graphene froths	Aspasia Antonelou, Vassileios Dracopoulos, Spyros N. Yannopoulos	10.1016/j.carbon.2014.12.091	Carbon (Elsevier Ltd)	2015	176-184
3	High-Quality, Reproducible ZnO Nanowire Arrays Obtained by a Multiparameter Optimization of Chemical Bath Deposition Growth	George Syrrokostas, Katerina Govatsi, Spyros N. Yannopoulos	10.1021/acs.cgd.5b01812	Crystal Growth and Design (American Chemical Society)	2016	2140-2150

Conferences announcements

	Title	Author(s)	Conference	Place	Year	Notes
1	R&D cooperation in technical textiles	Vincent Jamier (LEITAT)	Textile2020	Brussels, Belgium	2014	Oral presentation
2	Advanced Personal Protective Equipment - The EU Projects SAFEPROTEX and SMARTPRO	Silvia Pavlidou (MIRTEC)	NN14 Conference	Thessaloniki, Greece	2014	Oral presentation
3	Lightweight, flexible and smart protective clothing for law enforcement personnel (SMARTPRO)	Vincent Jamier (LEITAT)	Ambience14 Conference: Scientific conference for Smart and functional textiles, Well-Being, Thermal comfort in clothing, Design, Thermal Manikins and Modelling	Tampere, Finland	2014	Oral presentation
4	Life Cycle Assessment on Personal Protective Equipment	Enrico Fatarella (NTT)				Oral presentation
5	SmartPro - Smart Protective Clothing for Law Enforcement Personnel	Melanie Hoer (RWTH)	ADITC- Aachen-Dresden International Textile Conference	Dresden, Germany	2014	Oral presentation
6	Thermal cross-linking of double bond side functionalized aromatic copolymers	D.N. Saranti Karamesini, K. D. Papadimitriou, I. Thanasoula, V. Deimede, J. K. Kallitsis (FORTH)	10th HELLENIC POLYMER SOCIETY CONFERENCE	Patras, Greece	2014	Oral presentation
7	Shear Thickening Materials for Protective Clothing	Marolda Brouta-Agnésa (LEITAT)	53e edition of the Dornbirn Man-made Fibers Congress	Dornbirn	2014	Oral presentation
8	Design and evaluation of a textile-integrated GS receiver	Vornholt, Kolja; Alshrafi, Wasim; Reiffenrath, Meike (RWTH)	19th International Student Conference POSTER 2015	Prague, Czech Republic	2015	Poster presentation (3rd place award)
9	Laser processing of SiC: From graphene-coated SiC particles to 3D graphene froths	Aspasia Antonelou (FORTH)	ICANS26	Dresden, Germany	2015	Poster presentation (Young researcher award)
10	Environmental impact of Body Armours by means of LCA	Enrico Fatarella (NTT)	7th European Conference on Protective Clothing	Cesme, Turkey	2016	Oral presentation
11	Lightweight, flexible and smart protective clothing for law enforcement personnel	Silvia Pavlidou (MIRTEC)	7th European Conference on Protective Clothing	Cesme, Turkey	2016	Oral presentation

	Title	Author(s)	Conference	Place	Year	Notes
12	Textile surface treatment using thermal spraying for improved performance protective panels development	I. Georgiopoulos, P. Ioannou, Z. Tatoudi, S. Pavlidou and C. Andreouli (MIRTEC)	AUTEX 2017	Greece	2017	Oral presentation
13	Thermal Spray coatings deposition on ballistic aramide textiles for improved performance protective panels development	I. Georgiopoulos, P. Ioannou, Z. Tatoudi, S. Pavlidou and C. Andreouli (MIRTEC)	EUROMAT 2017	Thessaloniki, Greece	2017	Oral presentation

Other dissemination activities

	Title	Partner	Event	Place	Year	Notes
	Exhibition booth with SMARTPRO poster and newsletters distribution	MIRTEC	NANOTEXNOLOGY 2014	Thessaloniki, Greece	2014	Poster and flyers
1	SMARTPRO	NTT	Bilateral mission between Prato and UK textile district on technical textiles	Huddesfield, UK	2014	Oral presentation
2	SMARTPRO flyers & SMARTPRO logo on LEITAT general presentation	LEITAT	Industrial Technologies Conference	Athens, Greece	2014	Flyers distribution
3	SMARTPRO newsletter	LEITAT	Terrassa International Textile Conference	Terrassa, Spain	2014	Newsletters distribution
4	SMARTPRO flyers	NTT	2nd International FR-Conference on Fire-safe Textiles and Plastics	Gand	2014	Flyers distribution
5	Flyers of SMARTPRO on the Stand of CIMA	CIMA	Techtextil	Frankfurt, Germany	2015	Flyers distribution
6	Flyers distribution	NTT	7th UTIB International R&D Brokerage Event	Bursa, Turkey	2015	Flyers distribution

	Title	Partner	Event	Place	Year	Notes
	Exhibition booth with SMARTPRO poster and newsletters distribution	MIRTEC	NANOTEXNOLOGY 2014	Thessaloniki, Greece	2014	Poster and flyers
7	Best practice for including public end users into Security Research Projects	Alícia Moriana (INT)	Connect-EU Day	Barcelona, Spain	2015	Oral presentation
8	SmartPro: smart protective clothing for law enforcement personnel	Schwab, Max; Hörr, Melanie; Gries, Thomas; Jockenhövel, Stefan	SALTEX: smart textiles & lightweight materials, Dornbirn	Dornbirn	2016	Poster presentation on trade fair
	SMARTPRO M28 Meeting in Aachen: Towards a new protective clothing for law enforcement personnel	LEITAT	Project Meeting	https://projects.leitat.org/?s=smartpro	2016	Blog Article
	3rd General Assembly of SmartPro in Patras – Protective clothing for law enforcement personnel	LEITAT	Project Meeting	https://projects.leitat.org/?s=smartpro	2016	Blog Article
	SMARTPRO researchers win Young Research Award at ICANS26	LEITAT	ICANS26	https://projects.leitat.org/?s=smartpro	2015	Blog Article
	EcoTexNano & SMARTPRO in press (Dornbirn MFC)	LEITAT	Project activities	https://projects.leitat.org/?s=smartpro	2014	Blog Article
	LEITAT @ SMARTPRO 1st General Assembly and Workshop	LEITAT	Project meeting	https://projects.leitat.org/?s=smartpro	2014	Blog Article
	LEITAT presenting SMARTPRO @ Ambience14 Conference	LEITAT	Ambience14 Conference	https://projects.leitat.org/?s=smartpro	2014	Blog Article
	LEITAT @ Kick-Off meeting of FP7-Project SMARTPRO	LEITAT	Project meeting	https://projects.leitat.org/?s=smartpro	2014	Blog Article
	SMARTPRO	LEITAT	Project presentation	https://projects.leitat.org/smartpro/	2014	Blog Article
	Discover new lightweight, flexible and smart protective clothing for law enforcement personnel	LEITAT	Dissemination workshop	https://projects.leitat.org/?s=smartpro	2017	Blog Article

	Title	Partner	Event	Place	Year	Notes
	Exhibition booth with SMARTPRO poster and newsletters distribution	MIRTEC	NANOTEXNOLOGY 2014	Thessaloniki, Greece	2014	Poster and flyers
	Best practice for including public end users into Security Research Projects	LEITAT	EU Connect Event	https://projects.leitat.org/?s=smartpro	2015	Blog Article

4 Conclusion

SmartPro project developed a total of nine products labeled as key exploitable results, that are in general relatively close to the market and some of them show a good potential for the upcoming years in terms of market development. The most outstanding result is the 3D knitted Kevlar® fabrics which is already being exploited in a private industrial project (confidential for the moment). Furthermore, the scale type composites for protective applications was successfully integrated into the new design of the body armour for the riot police to protect body parts that need more flexibility of movement such as the legs. This new design shows also a good potential to enter the market although the specific requirements of each market makes it very fragmented and thus difficult to control. In addition, the lightweight and flexible protective panel shows good results in terms of ballistic (IIIA) and stab protection (I). Its weight is below 5.8 kg/m^2, which leaves room for improvement. Last, the smart functionalities have been developed successfully although some improvements in terms of connection and comfort.

As said, SmartPro shows various good results and products that are relatively close to the market although a final integration and demonstration of the armour is not completely accomplished. The dissemination of these results has also been intense and wide featuring good research results although a fully integrated body armour would have improved the efforts significantly.