



Project IST-034144: SToP  
**Stop Tampering of Products**

## Deliverable 7.10

### **Final Activity Report**

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## Project Details

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<b>Project coordinator organisation</b>	SAP AG

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## Version History

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# 1 Project Execution

## 1.1 Project Objectives

The SToP project was driven by the need for an effective and efficient tool to fight product counterfeiting. The counterfeiting problem is growing worldwide, affecting more and more product categories and industry sectors. Counterfeits damage the reputation of brand owners, produce economic losses, promote inferior working conditions, and put the safety and health of consumers at risk. Conventional anti-counterfeiting measures including cost-intensive field investigations, case-by-case analyses, and legal actions have so far not been successful in containing the problem and are not suitable for protecting mass produced items in a globalized market.

The overall aim of the project was thus to develop an anti-counterfeiting tool based on an in-depth understanding of the problem area and its broader context, the requirements regarding anti-counterfeiting systems stemming from a diverse set of industries, an analysis of the shortcomings of existing anti-counterfeiting approaches and taking into account the recent developments in the area of ambient intelligence and RFID technology that open up new possibilities in the fight against counterfeiting. In some industries, e.g. the pharmaceutical industry, some countries have already started to demand systems that would support the identification and authentication of products on a per-item basis. This was an additional motivation to work on a solution that would yield a unified approach that could be used globally.

The SToP project approached the counterfeiting problem from a largely technical perspective, while not neglecting its social and economical implications. The main motivation was the demand from brand owners for a tool that helps them to protect their brands effectively. Therefore “mechanisms” should be developed that would help to achieve this goal. The project consortium summarized its approach in the following mission statement:

*Mission statement:*

SToP will develop secure, comprehensive, usable, cost effective and convenient **product authentication mechanisms to reduce trade with illicit products**

This mission statement led to the formulation of three objectives that would guide the research and development work in the respective work packages.

*Objective 1:*

**Analysis of the structure, mechanisms and extent of illicit markets and the supply- and demand-side drivers of trade with counterfeit products**

This objective is concerned with the analysis of the problem space. Reliable knowledge about the markets for counterfeit products and the players that are active on these markets is rare, but the more is known about the operations of counterfeiters, the more targeted can the development of anti-counterfeiting tools be. The SToP project thus aimed at creating relevant knowledge as well as at providing a framework that would help brand owners and other stakeholders to gain a better understanding of counterfeit markets.

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*Objective 2:*

Development of a **business case framework** to assist government and companies (especially SMEs) to **calculate the impact of illicit trade on brand name and revenue**, the required financial investments and ROI

The business case framework is a step towards a standardized approach of calculating the costs and benefits from using anti-counterfeiting solutions, which is necessary in order to support the broad acceptance of such solutions. Without such a calculation, it is impossible for organizations to take an informed decision about the use of tools.

*Objective 3:*

Development of a **distributed software architecture**, enabling **enterprises** and end-users to efficiently manufacture, deliver and purchase **secure and authentic** products

This objective refers to the design and development of the anti-counterfeiting tool. It shall enable companies to integrate authentication and anti-counterfeiting functionality as part of normal business operations, while providing acceptable levels of security, reliability, convenience and cost effectiveness. Anti-counterfeiting measures are highly information-intensive. They are more than a security feature that is applied to a product. The management and integration of authentication relevant data must be streamlined, and a standard software module would greatly reduce the effort required to do that. The third objective thus subsumes the development of a distributed software infrastructure, the design of authentication approaches, the provision of suitable smart tagging technologies, the integration of the solution into business processes, as well as the evaluation and testing of the individual components.

## 1.2 Contractors Involved

The following contractors have been involved in the SToP project. Each of them has provided the project with knowledge from a unique background and with different industrial applications in mind.

Contractor name	Industry
SAP	Business software
Novartis	Pharmaceutical products
Richemont	Luxury goods
Airbus	Aircraft
Bundesdruckerei	Security solutions
SPACECODE	Automatic identification systems
ORIA	Business software
University St. Gallen	University

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### 1.3 Work Performed

A detailed understanding of the problem of counterfeiting was needed to derive sound requirements for solutions based on ubiquitous computing and ambient networks. The SToP project thus analyzed the main drivers and mechanisms of illicit trade, the roles of the different licit and illicit actors, as well as the supply and demand side of product counterfeiting. In particular, this included an analysis of producers of counterfeit goods, distinguishing different categories of counterfeit producers with different strategies, and an analysis of the flow of counterfeit goods in the supply chain. The role of consumers was investigated, particularly their awareness and buying behavior, as well as their reasoning for and against purchasing counterfeit goods. Furthermore, weak points within licit supply chains were identified and the properties of products which are most susceptible to tampering and counterfeiting characterized. To obtain these results, an extensive literature review was conducted as well as surveys among affected organizations and in-depth interviews with the project's industry partners.

A series of workshops and interviews with industry partners furthermore clarified the technical, organizational and business requirements for an anti-counterfeiting infrastructure. The discussion led to the definition of scenarios and authentication use cases relevant in various industries. The requirements engineering further encompassed the needs of brand owners and manufacturers regarding the desired levels of security for different types of products, as well as the requirements concerning the integration of smart tags for individual products. Furthermore, requirements for the protection of end-user and consumer privacy were derived. In the course of the project, it was continuously evaluated whether the proposed authentication approaches and the design of the anti-counterfeiting infrastructure met the requirements voiced by brand owners.

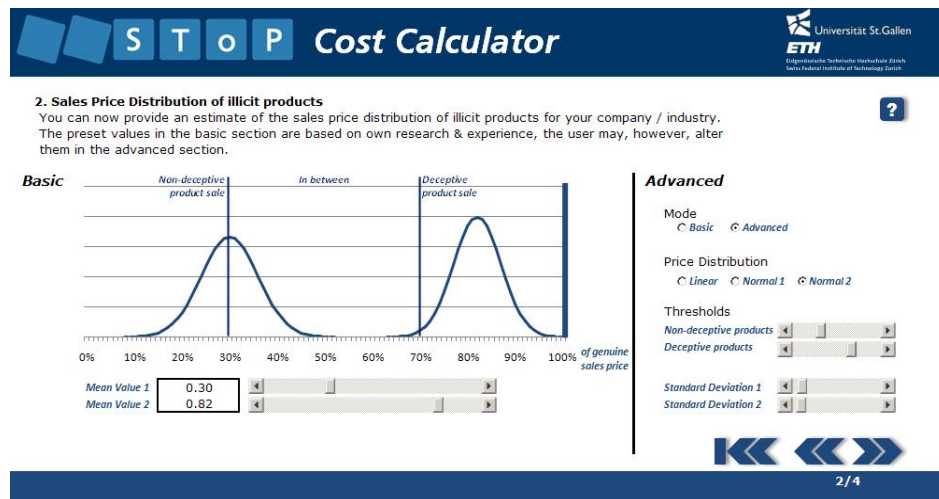
A further objective was the development of business impact models to provide an economic justification for pursuing the development and implementation of ambient intelligence based product authentication. More specifically, a framework for evaluating the financial impact of illicit trade on enterprises was developed. In this direction, an analysis of state-of-the-art methods was made and a solid methodology with the corresponding models to calculate the financial impact of counterfeiting was presented. The activities have been focusing on development a modular model, being theoretically grounded and methodologically sound. Here, the role of different actors (in the supply and demand side) of licit and illicit goods, product and supply chain specific characteristics (as they affect the costs and risks associated with counterfeit goods) have been considered.

The accompanying cost analysis focused on three main elements: implementation costs of the required infrastructure, costs per security feature which is applied to an individual product as well as production specific cost of integrating security tags into products, and overall costs (terms of time-per-check if carried out by a person or the much lower communication costs in case of fully automated checks). Key cost drivers were identified by looking at similar IT implementation projects and methods of quantifying these cost drivers were discussed.

The SToP cost calculation tool that supports companies in deciding which authentication technology to use was implemented, tested and documented. It allows choosing from 16 different anti-counterfeiting approaches based upon industry, supply chain, and product characteristics. For each technology, distinct attributes were assigned, e.g. in terms of provided security level, allowed authentication speed,

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or supported product consistency. In a second step, cost categories were specified to be included in the tool. They were classified as one-time and recurrent costs. Corresponding values for the different costs were derived together with the project partners. Both technology selection logic and technology costs were then translated into the Excel-based calculation tool.



**Figure 1. A framework to evaluate the financial impact of illicit trade**

The results of the business analysis tasks were then combined into an easy-to-use business case framework. Special attention has been given to the requirements of small and medium sized enterprises. To exemplify the application of the framework, concrete business cases have been calculated for the luxury goods industry as well as for the protection of security relevant spare parts.

As a foundation for the design of the anti-counterfeiting infrastructure, a thorough analysis of the state of the art on ambient intelligence based approaches for secure product authentication was conducted. Authentication approaches that operate with further technologies were also included in the analysis to complete the picture. Existing approaches that are used today in the business world have been discussed with industry experts, and emerging concepts that support secure product authentication with a focus on mobile and standalone approaches have been surveyed. Also different track and trace methods (e.g. RFID vs. 2-D barcodes) have been analysed and compared and their applicability in specific domains has been considered.

A major task in the project was the design, implementation and documentation of the anti-counterfeiting infrastructure and the design of novel, ambient-intelligence based authentication approaches. The infrastructure provides mobile and stand-alone applications and devices with proper services and the related data to easily verify the authenticity of products, particularly in the pharmaceutical, luxury goods, aviation, and security document industries.

Building on the requirements and use case analysis, the distributed infrastructure was designed and prototypically implemented. The development of the system followed a cyclical approach. The prototype was evaluated, particularly during the trials, and the design adapted according to the evaluation results. Major design efforts concerned the identification of relevant product authentication information and the definition of

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corresponding data models, as well as the development of security concepts. Since security is the heart of the SToP approach, security concepts for authentication were investigated as well as mechanisms for access control, trust management and delegation that are necessary in a largely distributed system.

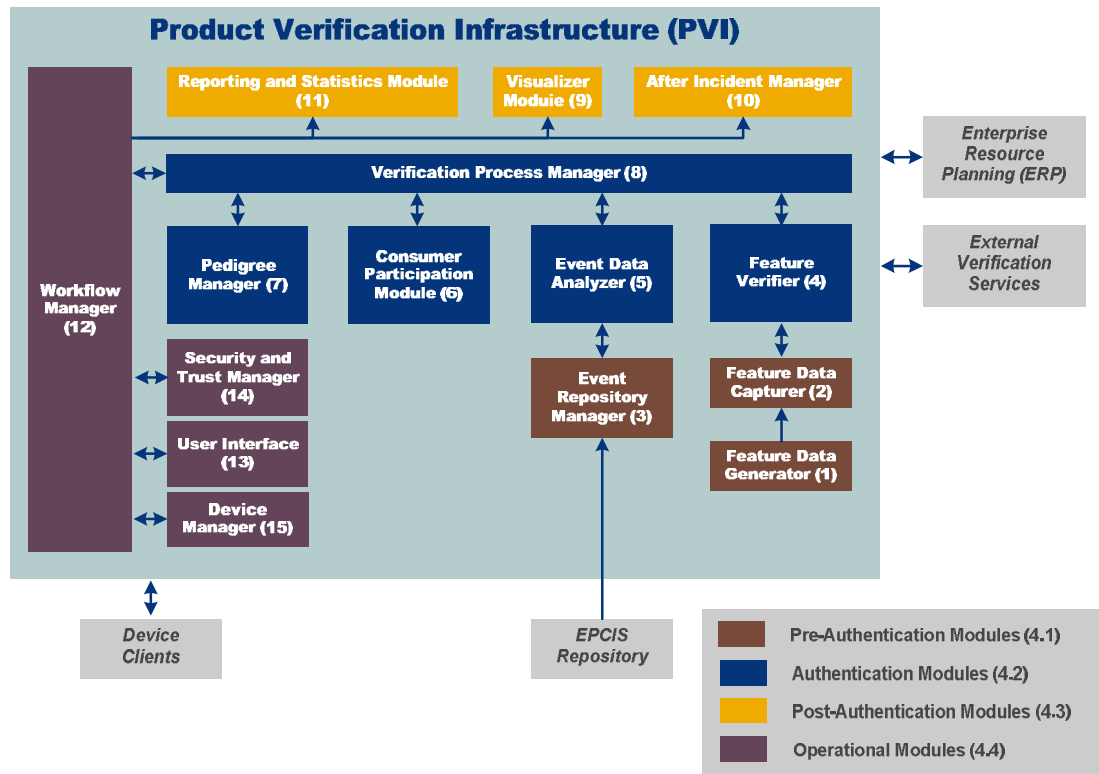


Figure 2. Architecture of the anti-counterfeiting infrastructure

While the anti-counterfeiting infrastructure is a generic software, it can and needs to be adapted to the use case scenarios in different industries, e.g. regarding business process integration, user interface and authentication devices. The prototype has thus been adapted to several lab and field trials and integration with numerous verification devices has been achieved. For example, for the aviation trial, a stand-alone system has been developed for use on a mobile computer that is able to update and authenticate service records that are synchronized between RFID tags and a server. The prototype was furthermore integrated with logistics software and the authentication processes in context of a logistics application was demonstrated.

The project furthermore investigated hardware related aspects of product authentication, i.e. the domain dealing with smart/intelligent devices and tags, as well as their integration in products during their production lifecycle. For each of the product categories targeted in the field trials (pharmaceuticals, plane spare parts, luxury goods) appropriate tags that comply with the manufacturing processes of a product had to be identified or developed. Here, different aspects of the product packaging and product materials needed to be studied and considered. A wide range of products from several vendors were tested and evaluated and suitable tags identified. A key challenge consisted in integrating the tags into real life products, which has been performed successfully, even under difficult circumstances. In this regard, a smart watch with an embedded RFID tag was developed. The main

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challenge was to achieve satisfying reliability while meeting the watch maker's requirements. In particular, there was a strong need to increase the reading distance of the RFID tag in a metallic environments.



**Figure 3. Embedded RF signature in a watch**

Necessary adjustments of manufacturing processes to enable production of tagged products were investigated together with industry partners. The results of this task have been found to be an important factor for the real-world applicability of the concepts. Here, new requirements imposed by the utilized smart tags, such as maximum pressure or temperature, have been taken into consideration.

The laboratory tests in the hardware domain focused on the improvement of a reading station to increase the usability at the point of sale and the development of a bulk reading station for mass authentication in environments such as distribution centers. For the pharmaceutical industry, RFID tags have been integrated into selected product packaging material in collaboration with suppliers of tags and suppliers of packaging material. Industrial runs with suppliers were conducted to ensure high quality of delivered tags.

The results of the software and hardware related work streams were finally integrated to prepare for the evaluation of the overall system in lab and field trials. The experimental lab trials integrated (preliminary) theoretical and practical results of all work packages in order to test early prototypes and also to simulate real-world circumstances.

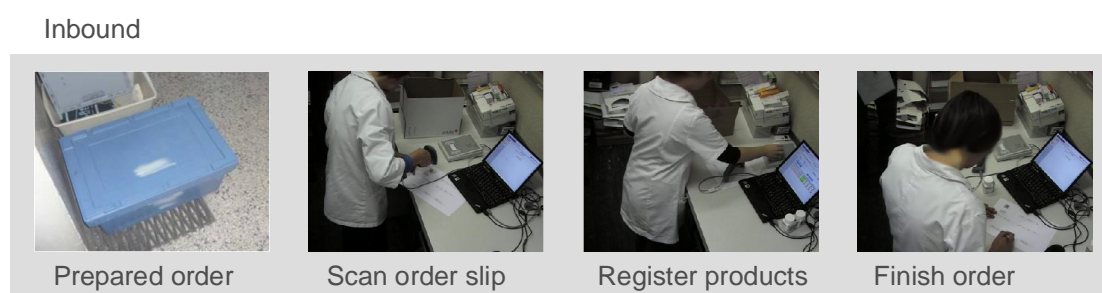
The lab trials were followed by the development and implementation of real-world application trials that have demonstrated our solutions in work. Thus, product authentication processes were integrated into existing or new supply chain processes (production, distribution, sales etc.). The real word application trials have considered product and production specific issues, being relevant for consortium member companies (in order to gain experience regarding mainly the quality, usability and interoperability of the proposed solutions).

For each industry represented in the project, one or several field trials on site at the partner companies were conducted. The field trials therefore required a careful and long term planning to ensure a maximum utilization of the time on site and to prevent unnecessary disturbances of the companies' operations. Trial goals, trial evaluation criteria and measurements instruments to assess the performance of each trial were developed beforehand and test cases and scenarios devised. During the trials, raw data was collected that enabled a comprehensive evaluation of the real-world trial results. The evaluation was conducted by analyzing the data gathered in the trials, including

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questionnaires, interviews, and observations. Both quantitative and qualitative results were presented with the focus on following points: usability of the final version of the authentication infrastructure, fit with work environment for the final system, achieved level of security in practice. In addition, industry-specific trial goals were evaluated, such as comparison of 2D bar codes and RFID.

The pharmaceutical field trial took place at a pharmacy and focused on the goods receiving process. The aviation trial focused on the maintenance and change of plane spare parts. The service technician is supported in the process by a mobile device with authentication capabilities. For the luxury goods industry, two different scenarios and products were chosen for the trials, and each trial consisted of two phases. This allowed to improve and adapt the anti-counterfeiting infrastructure based on the results of the first trial phase. All trials were run successfully and demonstrated the practical applicability of the solution in a business context.



**Figure 4. The main steps of a trial run in the pharmacy trials**

Also, application guidelines that reflect technical issues, and cover required organizational changes and marketing and public communication advices were derived based on the general findings of the project, and the trial results in particular.

Various dissemination and exploitation activities have been continuously performed in the course of the project. At first a strategy was defined outlining the means, methodology and procedures for dissemination and exploitation of the results. Basic activities included setting up a project website and a project internal collaboration platform. A regular newsletter that informed interested stakeholder about project activities and results was published. Further activities included submitting publications to scientific journals and conferences, and participating in industry events showcasing project results as well as participating in standardization activities.

## 1.4 Results

Before presenting the main project results, the outcome of the project shall be critically assessed in the broader context of anti-counterfeiting activities. It must be noted that the developed solutions are no silver bullet in the fight against counterfeiting, and they cannot be. First, there seems to be a natural demand for counterfeit goods that will almost always be matched by a supply. A parallel market for such goods thus evolves, which cannot be completely prevented.

In industries such as the pharmaceutical and aviation industries, the target group for a counterfeiter is typically composed of specialists, such as a pharmacist, or an aviation engineer. Counterfeit products can only be injected into the supply chain if they comply with the quality procedures that usually exist within such settings. For a pharmacist, this comprises checks regarding the package and expiration date, but a

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pharmacist also retrieves supply usually only from a small number of sources. Such a supply chain can be regarded as closed, and it is difficult for counterfeiters outside of the supply chain to inject products. Market liberalization, which would force such supply chains to open, is often regarded as a threat to their integrity, and consumers might be exposed to an increasing number of counterfeits.

In the aviation industry, there is no such linear supply chain as spare parts for airplanes have to be available world-wide and are often applied by contractors. The security in this case heavily relies on thorough documentation of all actions performed on parts. If documents become inconsistent or irregularities during work on spare parts come up, such parts are classified as “suspected unapproved parts” and are supposed to be eliminated from the supply chain.

In both cases, pharmaceuticals and aviation parts, the supply chain depends on the integrity of the involved personnel. Checks on products or documents are clearly ineffective if they are not thoroughly executed or if consequences are not drawn. Automated checks, which are automatically documented, could greatly enhance the security.

The market for luxury goods, including products such as clothing and accessories, is quite different. Customers are non-experts, and products are purchased usually not for functional reasons but for the “experience” and interpersonal value they provide. These aspects at the same time provide a motivation to buy counterfeit products consciously for customers for which genuine products are out of reach. This is in contrast to the other industries, where customers are interested in using only legitimate products.

The objectives set for the SToP project were therefore carefully formulated as to better understand the problem and to support the fight against counterfeiting with novel tools and applications. The following project results were created in the course of the project to achieve these objectives:

- Understanding of the problem area, elicitation of technical and business requirements regarding an anti-counterfeiting infrastructure:
  - Clustering of counterfeit producers along their main characteristics, revealing the existence of five distinct strategic groups
  - Identification of the weakest links in licit supply chains
  - A consumer study revealing the characteristics of counterfeit buyers and their motivations for doing so
  - Description of the drivers and enablers of counterfeiting in selected industries
  - Description of the requirements for a technical anti-counterfeiting infrastructure, in particular the identification of use cases and scenarios
  - A description and comparison of existing technical countermeasures
  - A tool that supports brand owners in deciding which products to secure based on attractiveness for counterfeiters and expected losses
  - A description of anti-counterfeiting best practices

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- An analysis of the business impact of counterfeiting in selected industries and tools for estimating the business impact, in particular:
  - A framework for evaluating the financial impact of illicit trade
  - A cost calculation tool that helps brand owners to assess the costs of anti-counterfeiting solutions
  - A business case calculation tool for assessing the benefits of anti-counterfeiting solutions
- A distributed anti-counterfeiting infrastructure and novel authentication approaches based on ambient intelligence, in particular
  - A state of the art analysis of authentication approaches, demonstrating the need for novel approaches
  - A validated design for an anti-counterfeiting infrastructure that meets industry requirements
  - A prototypical implementation of an anti-counterfeiting infrastructure and ambient intelligence authentication approaches
- Solution engineering for tags, devices and item manufacturing, in particular
  - A watch using an embedded RF signature and a corresponding reading station
  - An analysis of the metallic impact on RF wave reading station for watch
- Integrated lab and field trials, in particular
  - Six field trials in selected industries
  - Application guidelines for anti-counterfeiting solutions based on the trial results

In summary, it can be concluded that the objectives of the SToP project were fully met. By conducting interviews with industry experts and surveys valuable knowledge about the problem domain could be gathered that adds to the scarce findings existing today. This knowledge can be valuable in supporting future anti-counterfeiting efforts. The cost-calculation tool and the business case framework are new tools that allow brand owners to further systematize and assess their fight against counterfeiting. The anti-counterfeiting infrastructure together with the developed novel authentication mechanisms advances the state of the art by utilizing the potential of ambient intelligence for counterfeit detection and offering a fully integrated, distributed and scalable infrastructure through which whole supply chains and industries can cooperate in fighting the counterfeiting problem. In the area of solution engineering, technologies for enabling the authentication of metallic goods and bulk authentication have been developed and successfully applied. Furthermore, the SToP project assembled a complete set of guidelines and best practices to support companies in the fight against counterfeiting. This set of guidelines is unique by having a broad industry scope, building on the results of field trials and being founded in a thorough analysis of the problem space.

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## 2 Dissemination and Use

The SToP project created a number of opportunities for exploiting the project results in all of the participating partner companies.

As a first major exploitation opportunity, web-enabled devices were identified. Modern software applications are often web-enabled due to usability, maintenance, and cost issues. In some applications, like product authentication, external peripheral devices are required to interact with the application, which essentially runs on a back-end server. A standard approach to this problem domain would greatly facilitate the design and maintenance of software systems that integrate client-side devices. In the SToP PVI, we have introduced a prototype for a component that provides remote accessibility for locally connected devices in a uniform, service-oriented way. This component provides a blueprint for future software designs that tackle similar problems. The approach is being introduced to software development groups in order to promote it.

A further exploitation opportunity is the technology selection support tool. Decision makers in companies that are interested in protecting their brands against counterfeiting are faced with a broad choice of technologies for product protection and product authentication. A tool that, based on a number of business-specific constraints, provides an assessment of available technologies greatly enhances the effectiveness and efficiency of a technology selection process.

A prototype for a technology selection tool has been developed within SToP, and has been demonstrated to product groups. The objective is that customers take the opportunity to evaluate the tool for their purposes so it can be further refined and offered as a standard support tool.

Similar to the technology selection tool, a business calculator can support the decision making process about the introduction of security feature for product protection. The tool allows calculating a cost estimate based on fundamental business figures.

The SToP prototype allows already some fundamental cost estimation based on business figures. The prototype will be presented to SAP product groups with the objective to have customers pick it up for evaluation purposes in order to obtain more experience with it. Based on this prototypical stage, a future standard tool shall be developed.

In the solution engineering domain, project results have already been integrated in real time in the RFID product portfolio of SPACECODE. These products are being promoted and sold into healthcare and luxury goods customers for use in their production, manufacturing, and packaging as well as logistics processes to eliminate counterfeiting and its consequences. Software has been developed to be able to provide on-line product authentication services for the users. Thus complete solutions are being commercialised, comprising

- RFID hardware: Tags and readers
- Software: Tracking and authentication data management
- Product integration: Affixing or integrating of tags into respective products in healthcare and luxury goods companies.

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For the industry partners, exploitable results consist to a lesser extent in products, but rather in contributions to a better understanding of the problem domain, affected business processes and preparedness. The luxury goods industry should benefit from an easy-to-use tool to verify the authenticity of products at any time, and possibly from improved collaboration with customs and other concerned authorities. The tool is foreseen to include a software application that can interface with a variety of authentication solutions (including RFID) along with guidelines for an efficient and successful implementation. Depending on the project progress and solutions yet-to-be developed, the project has resulted within the project timeframe in demonstrations, prototypes and pilots, together with the related recommendations and documentations.

These deliverables are expected to help all luxury goods companies in defining and implementing anti-counterfeiting means and advanced product tracking intelligence for relevant stakeholders.

In the pharmaceutical industry, the SToP results contribute to the implementation strategy for unique serialization and product tracking of pharmaceutical goods which is a long term endeavor. In the case of RFID serialization, it was decided to select tablets in plastic bottles to avoid shielding of radio frequency through liquid drug products or metallic packaging components. This limitation is not valid for 2D Datamatrix coding technology. The preparation of the samples for the pharmacy trial and the subsequent large-scale, on-line and high-speed serialization revealed a much better reliability of 2D Datamatrix over RFID UHF Gen2 tags at much lower operating cost. The SToP trials revealed issues to read the 2D datamatrix codes printed on-line. This is related to the lower resolution of hand-held 2D datamatrix code readers as used in pharmacies compared to high-resolution readers used on packaging lines. As a result print quality of 2D datamatrix code must be increased on the packaging line to ensure reading at lower reader resolution in pharmacies. The Pharma trial revealed problems with graphical layout of the artwork – leading to poor readability of 2D Data Matrix codes. The early detection of this problem avoided significant remediation cost following subsequent implementations. In the meantime, various trials in the pharmaceutical industry confirmed the results of the SToP pharmaceutical trials. Consequently, 2D datamatrix code according to GS1 standards has been selected for the coding trial of European Federation of Pharmaceutical Industries and Associations, which will be executed later in 2009.