TagItSmart
Smart tags driven service platform for enabling ecosystems of connected objects

Grant agreement 688061

Open Call Deliverable Report for

HoneyTag – Brand protection and Quality Improvement for Montenegrin Honey

– Technical feedback – lessons learned –

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Contents

PROJECT OBJECTIVE 3

PERFORMED ACTIVITIES SO FAR 3

Smart label specification and design **3**

Digital product semantic model **4**

Smart labels printing **5**

System architecture **7**

Use cases diagram **8**

API calls **9**

Mobile application **10**

Website **11**

CONCLUSIONS 12

Project objective

The aim of the HoneyTag project is protection of both brand and geographical origin of Durmitor's honey. The TIS components and solutions are utilized in order to perform this goal.

Each honey jar is marked with smart labels representing combinations of QR code and functional inks. These markers coupled with mobile app and cloud platformprovide:

- Unique identification and tracking of each honey jar,
- Mechanism for anti-counterfeiting,
- Food safety control,
- Interaction with consumers and
- Promotion of producers' business activities.

The unique identification of honey jars is accomplished combining string coded in QR code and letter printed by functional ink. Consumers are used as sensors indicating three states of jar: consumed, quality problem and everything is ok. This provides the second layer of anti-counterfeiting mechanism. The first one is printing of letter using functional ink.

As added value, the jar labelshave thequality control functionality also. According to the food safety rules, the honey should not be exposed to temperature greater than 45 ^{o}C. Therefore, the jar label is equipped with the temperature threshold sensor indicating bad storage conditions. To indicate quality issue, the thermochromic irreversible ink provided by TIS partners is used. The honey quality is also monitored using the costumers' feedback trough the rating product functionality.

Beside of honey production, many of beekeepers have some additional business activities. For example, they rent accommodation and have restaurants with traditional food. In order to link their business with honey production, the app used for scanning jar labels provides additional data about the producer giving ability to get in touch with them. The app haslinks to site from which customer can make direct contactwith the producer.

Performed activitiesso far

In this section, we describe results of HoneyTag project technical activities during the reporting period. These activities include:

- smart label specification and design,
- system architecture design and realization, as well as
- Project website launching.

Smart label specification and design

In the design of smart labels, the goal was to provide an efficient mechanism for both anti-counterfeiting and honey quality control. Investigating the technology available within the TIS project, it is decided to use QR code-based module and two functional inks, photochromic and thermochromic ones, provided by different TIS partners.

The smart label design for all possible states is shown on Figure 1. The label consists of the QR code, letter printed with reversible photochromic ink and honeycomb painted with irreversible thermochromic ink. When it

is illuminated by UV light (contained in flesh light of mobile phones),the letter appears and in combination with content of the QR code provides unique identification of honey jar. After illumination, the letter is visible for a period of time giving the capturing ability to a mobile device and checking validity of the unique ID.

Anti-counterfeiting mechanism consists of three levels of security: *unique product URL* contained bythe QR code, *unique combination of this URL and a letter* and *functional ink* that is hard to counterfeit. The example of the QR code content is given in the following

https://api.tagitsmart.eu/products/ME0000A00A001M00000KHZ000

The honeycomb is used as quality control sensor. In normal state, it is painted by white color. If storage temperature exceeds 50 ^{o}Cfor at least one minute, the paint will become magenta indicating food safety issue.

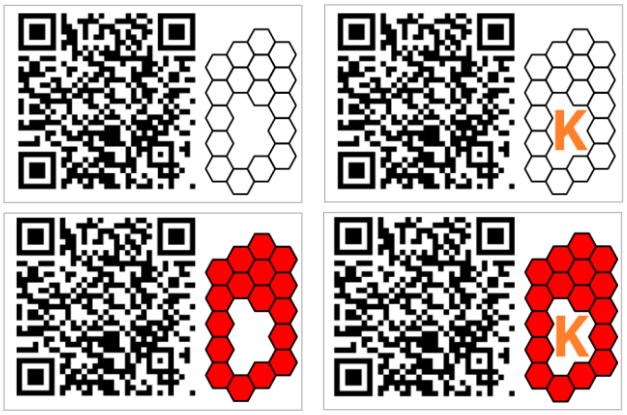

Figure 1 - Smart label design.

The functional ink requirements are given in Table 1.

Ink	Trigger	Response time	Previous state
Photochromic	UV light illumination	Less than 10s	Reversible
Thermochromic	Temperature above 50 ^{o}C	Less than 1 hour	Irreversible

Table 1 - Functional ink requirements for smart labels.

Table 2illustrates technical characteristics of used smart inks as well as lamination type.

Ink	Manufacturer	Type
Photochromic	Durst	FC513/514
Thermochromic	VTT	KROMAGEN W/B FLEXO INK MAGENTA 60°C
Lamination		RI837/85 PE GLOSS CLEAR TC8 AP901 W

Table 2- Ink and lamination specifications.

Digital product semantic model

The digital product semantic model based on the smart label design (Figure 1) is shown on Figure 2.

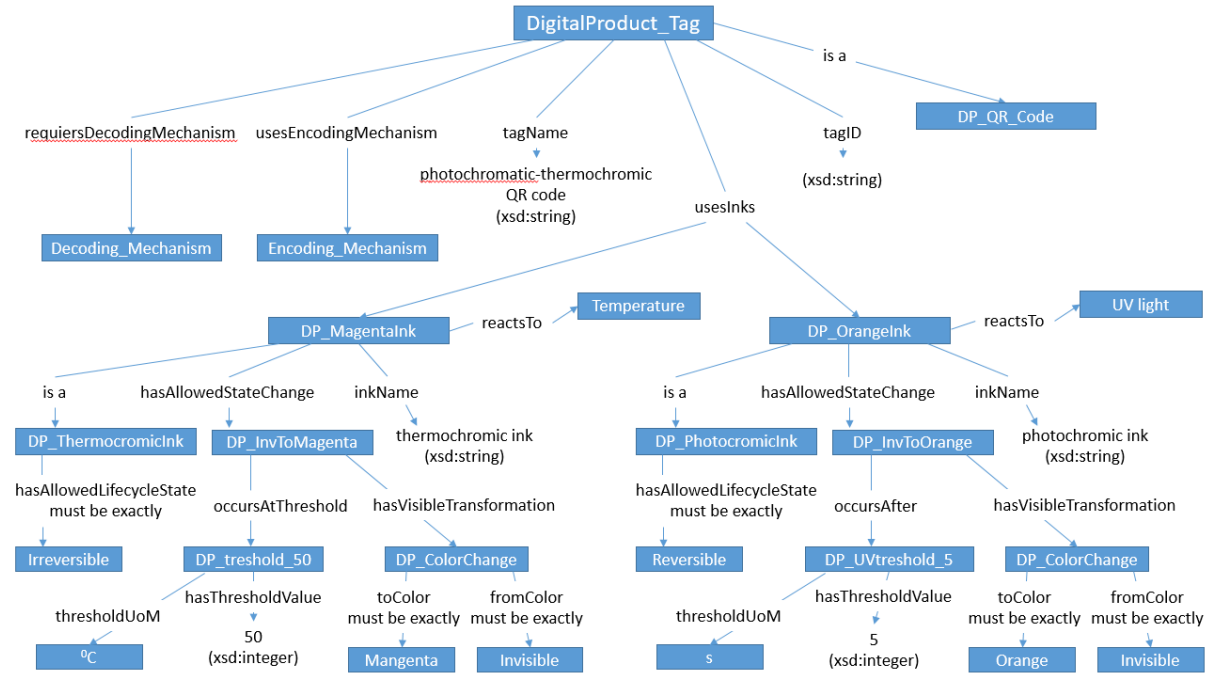

Figure 2 - Digital product semantic model.

Smart labels printing

The project goal is to evaluate the technology with six honey producers. Each producer has two products: *Livadski med 500g* and *Livadski med 1000g*. Thus, we have prepared 150 smart labels per each product. The plan is to mark 1200 honey jars, while left over labels will be used for testing purpose.

The label printing required preparation of three separated files considering digital prints design (QR code with honeycomb borders), reversible photochromic prints design and irreversible thermochromic prints design.

The labels printed by DURST and VTT were received beginning of July. For testing purpose, part of labels is printed with lamination, and part of them are without a lamination.

Labels are tested and reactions of functional inks for different scenarios are illustrated on Figure 3.

without lamination - sun light

with lamination - sun light

without lamination - UV lamp

without lamination – 60^{0}C exposure

with lamination – 60^{0}C degree exposure

without lamination – flash light Samsung j5

Figure 3 - Reactions of smart labels after exposing them to sun light, UV lamp, mobile phone flash light and temperature of 60.

As it can be seen, depending on the UV illuminator type, photochromic ink reacts differently.

For UV lamp and sun light the ink has full visibility, while for mobile phone flesh light visibility is significantly reduced. Our tests have shown that for some mobile phones, such as Xiaomi RedMi 5 Plus, there are no reactions after flesh light illumination.Lamination has no effects on the performance of photochromic ink.

Exposure of the label with no lamination at the temperature of 60^{0}C causes reaction of the thermochomic ink, while that was no case for laminated label.

The automatic letter detection and recognition of honeycomb states are challenging tasks due to the following reasons:

- Light-colored letters or honeycomb can be removed from images duringthe acquisition process;
- Letter overlapping with honeycomb caused by printing process can have influence on character recognition performance;
- Some mobile devices will not cause ink reaction;
- Laminated labels are not useful for quality control.

For this task the plan is to utilize Azure Custom Vision API or to develop our own procedure.

We are going to use as much as possible labels from the first print. The second printing is scheduled for September.

System architecture

The HoneyTag system architecture is already elaborated in the previous report – D 1.2 (Figure 4). During the period covered by this report all system components are established and integrated.

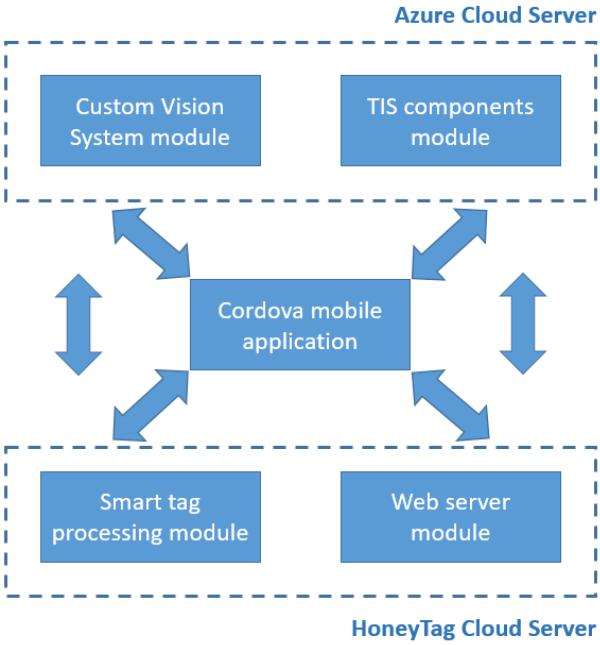

Figure 4 - System architecture.

Three main building blocks can be identified: Cordova mobile application, Azure Cloud Server and HoneyTag Cloud Server. Mobile application is in core of the system enablingend-user interaction with all TIS components. Based on smart tag scanning, the application provides quality and originality checks, user feedback, product information and links with producers' direct contact. The TIS API, placed on Azure Cloud Server within TIS components module, is used for digital products creation, smart tags generation and customer reviews collection. The Smart tag processing module of HoneyTag Cloud Server generates and validates combinations of unique strings contained by QR codes (obtained using TIS API) and letters that are printed by reversible photochromic ink.It also prepares scanned smart tag images for recognition by Azure Custom Vision

(ACV)System module. The role of the ACV system is to read sensor states, i.e. to perform letter and honeycomb state recognitions. Presentations of the Project and all producers with contact forms are placed on Web server that is a part of HoneyTag Cloud Server.

The main components of the HoneyTag application are illustrated on Figure 5.

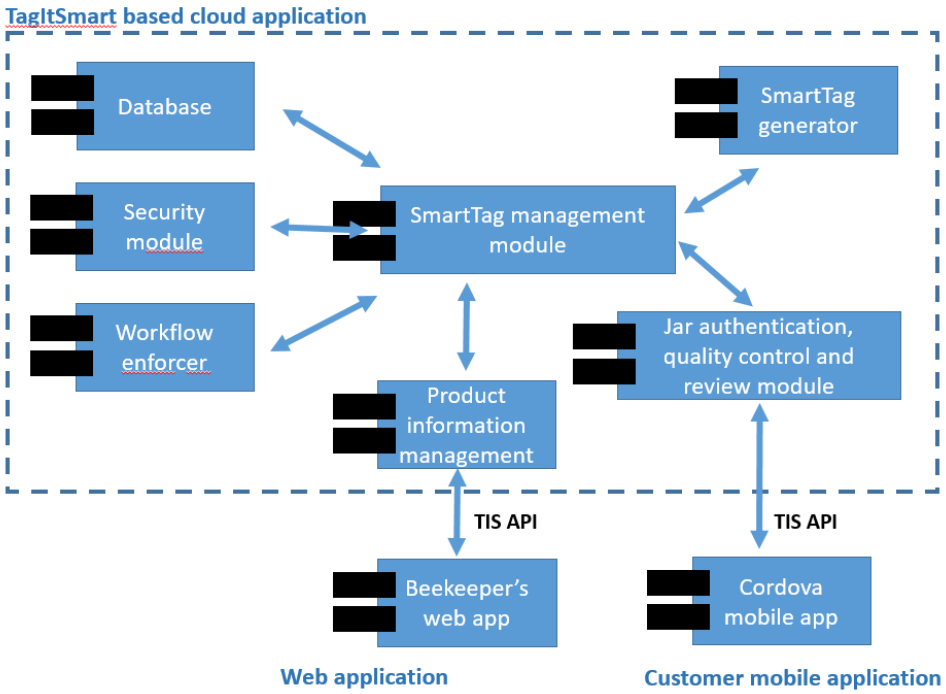

Figure 5 - HoneyTag component diagram.

Due to challenges elaborated in Smart label printing section and facts that printed smart tags are received at the beginning of July, the training of ACV system for performance improvements is not yet finished. Besides the training, in parallel, we are investigating the development of our own system for reading the sensor states in case that would give improved results.

Use cases diagram

The HoneyTag use cases diagram is shown on Figure 6. Three stakeholders can be identified: customer, producer and Union of Beekeepers Associations (in further text *BeekeepersUnion*). The customer checks the product information including originality and quality by scanning jars tagged with smart labels. He also has the ability to provide information about satisfaction with the product as well as to post quality issue complaint. In order to obtain smart labels and perform jar tagging, the producer sends requests for specific number of tags to the Beekeepers Union. Union prints smart labels based on real producer needs and also performs measures for product withdrawing from sale after quality complain is obtained.

Figure 6 - HoneyTag use cases.

API calls

API calls used by HoneyTag mobile application and backend for tag creation and printing are listed in Table 3.

Access	API Call	Description
POST	http://api.tagitsmart.eu/account/login	Authentication
GET	http://api.tagitsmart.eu/account/logout	Logout
POST	http://api.tagitsmart.eu/products/create	create [Digital Product]
GET	http://api.tagitsmart.eu/virtual-entities/batches	read all batches
POST	http://api.tagitsmart.eu/virtual-entities/batches	create a batch
POST	http://api.tagitsmart.eu/producer/smart-tags	generate smart tags
GET	http://api.tagitsmart.eu/producer/download-smart-tags	download smart tags
GET	http://api.tagitsmart.eu/producer/products	products list
GET	http://api.tagitsmart.eu/producer/products/{id}	product info
GET	http://api.tagitsmart.eu/products/review	get product reviews
POST	http://api.tagitsmart.eu/products/review	add product review

Table 3 - TIS API calls used by HoneyTag project.

To more efficiently use TIS architecture, in some fields of the API returns we have encapsulated additional fields in the form of string that can be decoded as JSON object.

Mobile application

Mobile application is developed and it is now in testing phase. It has been written using Cordova HTML5-based cross-platform framework meaning that it can be easily compiled to Android, iOS and Windows mobile applications. Currently, due to available hardware, only Android application is in the process of testing.

Screenshots of application are illustrated on Figure 7. Application starts withsplash screencontaining HoneyTag logo. After establishing communication with TIS API, welcome screen appears.

This screen offers options for getting information about the product, product rating, sending complains about the quality issues and getting information about all producers/beekeepers.

To get product information, send review or post complain, user first has to scan smart label. If scan is successful, adequate page opens. Both originality and quality sensor states are included in product information. If jar is rated, it is automatically marked as consumed and it cannot be rated again. The similar situation is for reporting quality issue. After each action, adequate help screen appears. Its appearance can be controlled from settings menu where it can be switch on or off. The same menu has option for choice of language. There are two available languages: English and Montenegrin.

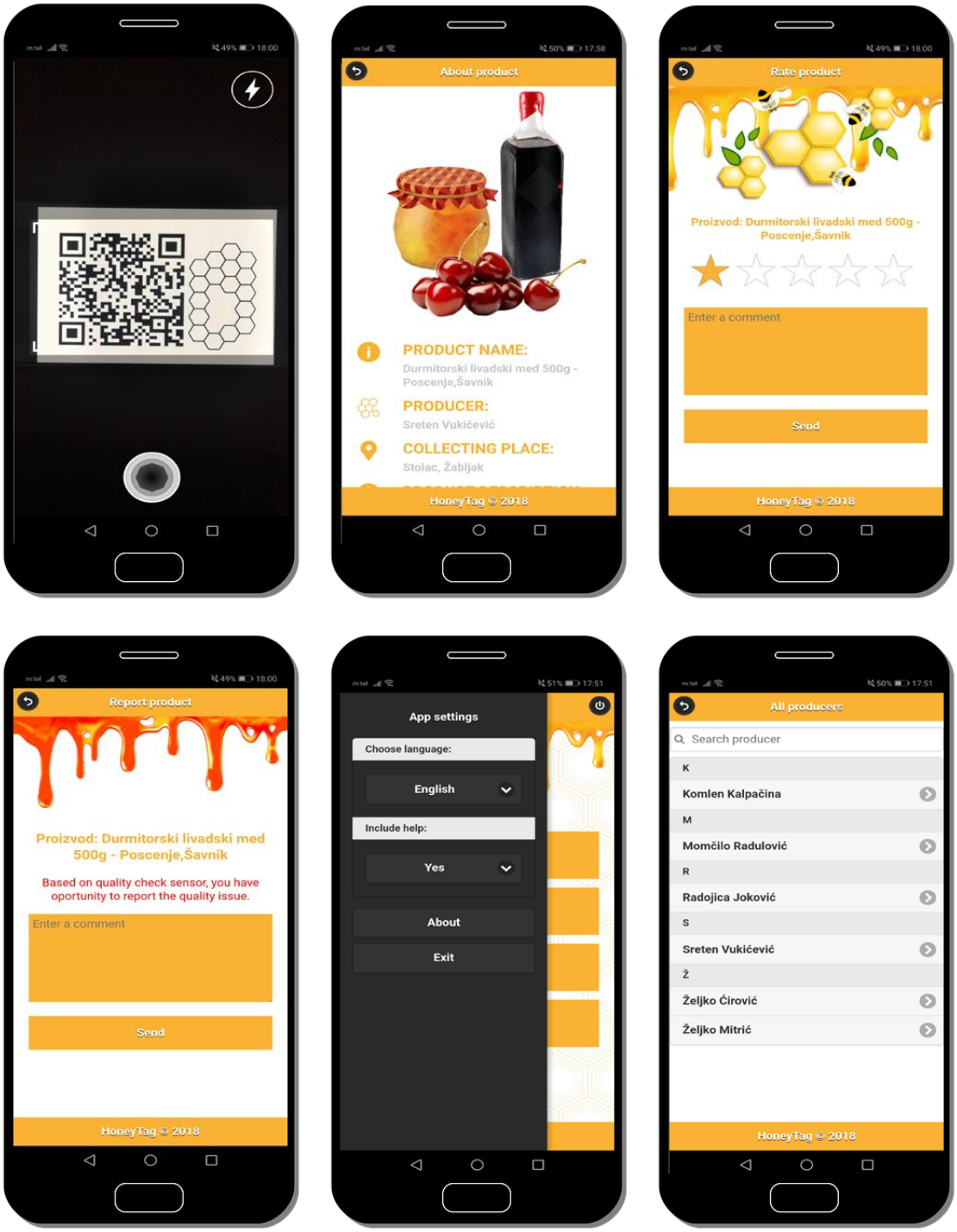

Figure 7 - Screenshots of HoneyTag mobile application.

Website

HoneyTag website (http://honey-tag.me/) is launched in orderto promote both the Project and business activities of all producers involved in this project. Site is responsive, i.e. adaptive to different screen sizes and

resolutions. It contains web forms for establishing communications between customers and producers, and has information about the project dissemination activities. The screenshot of welcome page is shown on Figure 8.

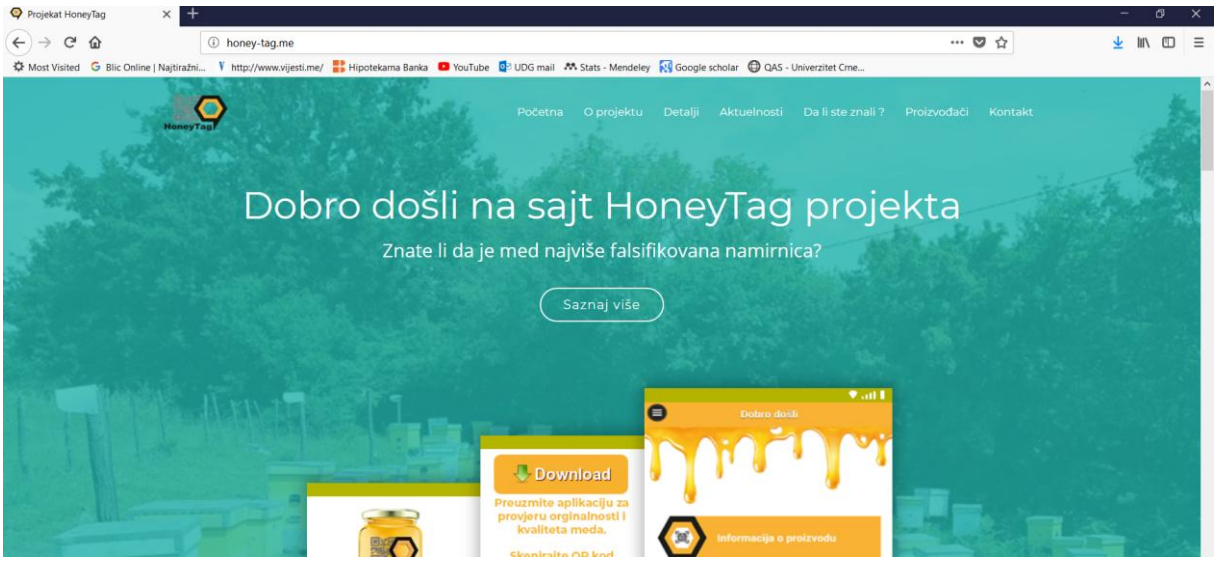

Figure 8 - HoneyTag website.

Conclusions

In this report, we have summarized performed activities regarding the HoneyTag platform implementation and integration. The label design and its functionalities have been described. First tests on printed labels have been done and testing results are elaborated. The implemented system architecture and use case scenarios are described in details.

During the next period, further testing of labels is planned. As previously reported, due to challenges elaborated in *Smart label printing* section and facts that printed smart tags are received at the beginning of July, we will continue the training of ACV system for performance improvements. Besides the training, in parallel, we will investigate the development of our own system for reading the sensor states in case that would give better results.We will rely on labels that we have to the largest extent possible, and by the end of August send inputs for the next labels printing scheduled for September.