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STRATOS: open System for TRAcTOrs' autonomouS Operations

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ABSTRACT

This paper describes the objectives and final results of the STRATOS project (System for TRAcTOrs' autonomous OperationS), within the framework of ICT-AGRI ERA-NET (Coordination of European Research within ICT and Robotics in Agriculture and related Environmental Issues). The main objective of the STRATOS project was the development of an open ICT hardware-software infrastructure enabling the acquisition of geo-referenced information on soil and terrain parameters.

In more detail, STRATOS project target was to develop and demonstrate new functions enabled by ISOBUS technology (ISO 11783) that support a substantial improvement of the quality of the farming jobs. In particular the idea is to develop a technology based on ISOBUS compliant, wireless self-powered sensor network for the real time measurement of soil and harvester conditions. In this way, Task Controller (an ICT component defined by ISOBUS specification which supervises actively the farming job performed by the tractor) can optimize the whole tractor and implement operational modes to improve the farming job quality and safety of the overall systems.

The project lasted from 1st April, 2011 to31st March, 2013, and this paper reports about the project achievements

Keywords: Isobus, wireless sensors, Israel, Italy, Latvia, Switzerland,.

1. INTRODUCTION

Soil is a complex, living, changing and dynamic component of the agro-ecosystem. It is subject to alteration, and can be either degraded or wisely managed. A thorough understanding of the ecology of the soil ecosystem is a key part of designing and managing agro-ecosystems in which the long-term fertility and productive capacity of the soil is maintained, or even improved. This understanding begins with knowledge of how soil is formed in a given ecological region, and includes integration of all the components that contribute to the structure and function of the entire soil ecosystem (Gliessman, 2004). A great many biological, chemical and physical factors determine soil quality. By measuring some of these components and determining how they respond to management in an agricultural context, a foundation for assessing the health

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of the soil can be established. Ultimately, indicators of sustainability can be grounded in the assessment of soil conditions and how they change as a result of the choices a farmer makes in managing the agro-ecosystem.

Measurements of soil and terrain parameters, such as pH and soil moisture, soil temperature and bulk density, water holding capacity, etc.; can be obtained by means of the analysis of optical and microwave remote sensing data (Mulder 2011), or by a set of suitable sensors placed on the field. In order to reduce the number of sensors and optimize the agricultural job, the sensors can be placed on board to a tractor which is moving within the area to be monitored. and or carried on the tractor or any other agricultural machine.

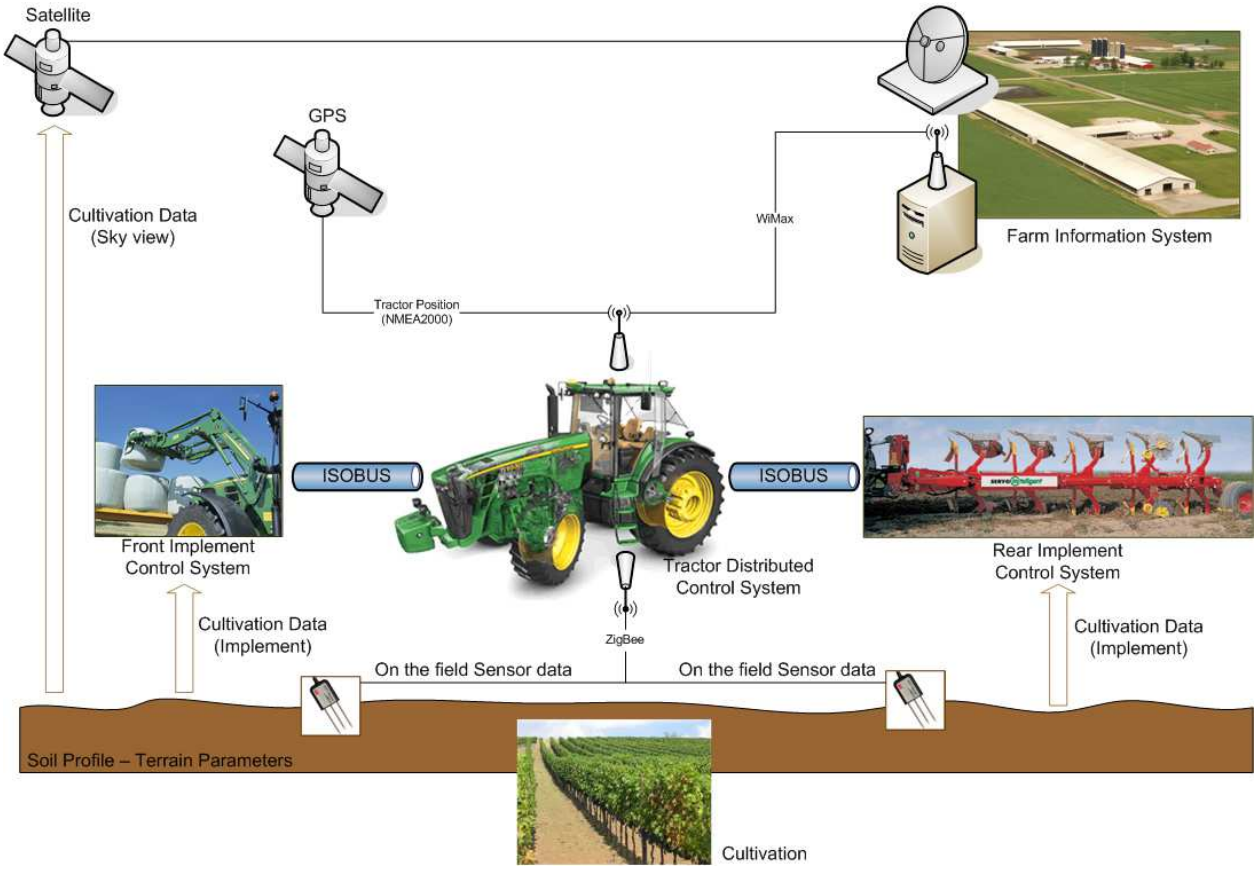

Figure 1. A integrated system for the acquisition of soil and terrain data from various sources.

The STRATOS project exploits the communication standard ISOBUS technology to implement a wireless sensor network for a mobile system for soil and terrain data acquisition through field sensors.

1.1 **ISOBUS standard**

A tractor or an implement taken apart are useless, as only the combination of the two of them performs an effective agricultural job. In the past, all tractors had a proprietary

hardware architecture to control implements, and in particular an ad hoc remote control system which must be installed in the tractor cockpit, often installed as an aftermarket kit. Since many implements should be plugged into a single tractor to accomplish various farming jobs, many control and user interface (HMI) devices have to be installed on board often producing a mess of cable and hardware, that prevent ergonomic and safe tractor use.

Since the early 90s' a task force of tractor and implement manufacturers, and standardization authorities is developing the ISO11783 norm (ISOBUS), that aims at introducing a "plug & play" concept into the tractor-implement systems. We give a set of components relevant from this papers point of view that ISOBUS specifies for tractors provided with ISOBUS certification (Oksanen T. et al., 2005), (Pierce, F. J. and Nowak P. (1999)):

- Virtual Terminal, a standardized control and user interface unit that enables communication of control and supervision signals with any ISOBUS-compliant implement. In such a way, all standard implement can share the same control and user interface unit, simplifying by far the work of the farmer and increasing the usability and, hence, the safety of the tractor.
- Task controller, a software application run by Virtual Terminal for the management of the agricultural job.
- Communication network, based on 2560kbaus CAN communication protocol allowing simultaneous bus access from different nodes.

2. STRATOS STRUCTURE

The aim of STRATOS project is to demonstrate the application of ICT technology, in particular ISOBUS and wireless communication technologies, to agricultural applications. The structure of the system can be described as follows:

a) The wireless sensors transmit every 30 seconds a data stream containing information in a digital coding through a network (Wireless Sensor Network, WSN).
b) The ISOBUS Task Controller is deployed in a Data Management System (DMS), which gets the continuous data flow from the sensor network, then format this data stream in a defined structure and send these structures to the remote FMIS (Farm Management Information System) into the farm premises.
c) The DMS gets stream of data from the WSN using a serial UART link.
d) The DMS gests the localization data from a GNSS receiver (standard GPS receiver) through an ISOBUS interface.
e) The DMS communicate with the FMIS using a GSM module hosted by the VE-CAN system. The DMS sends the stream of data to the VE-CAN module through the ISOBUS network.
f) The DMS has a human interface which is based on a smartphone connected via blue tooth that permits the user to interact with the STRATOS system to command: (1) start stream (data collection and communication to FMIS), (2) stop Stream, and to display information about (3) communication channel status (working/not working) and (4) average value for each sensor.

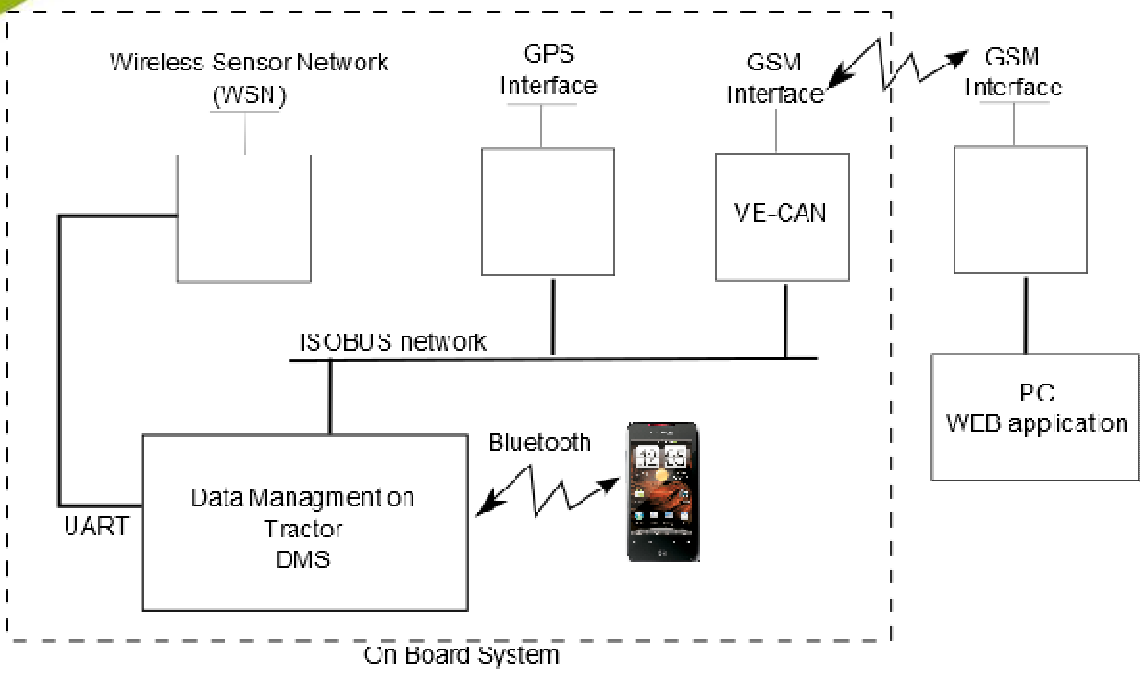

Figure 2. The STRATOS structure.

The system implements the following use cases:

1) The DMS hosted by a ECU on board to the tractor gets the data flows from the wireless sensor network WSN through the UART dongle (access point for the WSN).
2) The DMS gets the position information from the on-board GPS through ISOBUS.
3) The DMS combines the two sources of information and formats the data in a defined structure, suitable for the communication to FMIS using the GSM interface.
4) The GSM interface is hosted by the VE-CAN module. The DMS sends data stream to VE-CAN module through ISOBUS.
5) The PC in the farm premises equipped with a GSM interface receives the data stream from the mobile station through the GSM communication channel.
6) The PC collects and stores the data in a database management system: DBMS.
7) The data are presented to the user by means of a web interface on the PC using also a google map visualization service.

3. STRATOS DEVELOPMENT

The development of STRATOS prototype followed the steps:

1. A conceptual model of the system has been developed using the Unified Modeling Language (UML), that is the standard formalism to structure the engineered development of complex systems. A complete conceptual description of the system has been developed using a set of graphical documents following UML syntax. These scheme have been used to share between project partners all the information concerned with the system development, allowing remote collaboration of engineering teams.

2. On the basis of formal specification derived from step 1, the STRATOS infrastructure has been divided in modules, which have been developed separately by partners on the basis of their own competences.
3. The last step was the integration of the subsystems in the complete STRATOS prototype.

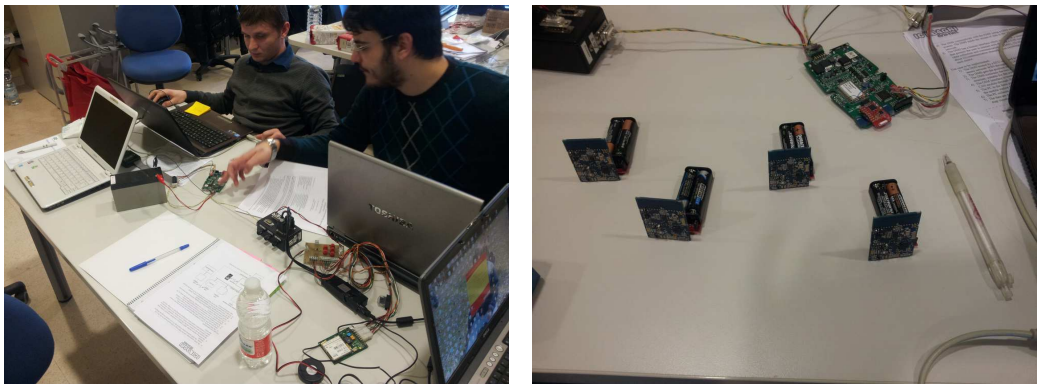

Figure 3. The development of the system in the lab (left) and the prototype of the wireless sensors (right).

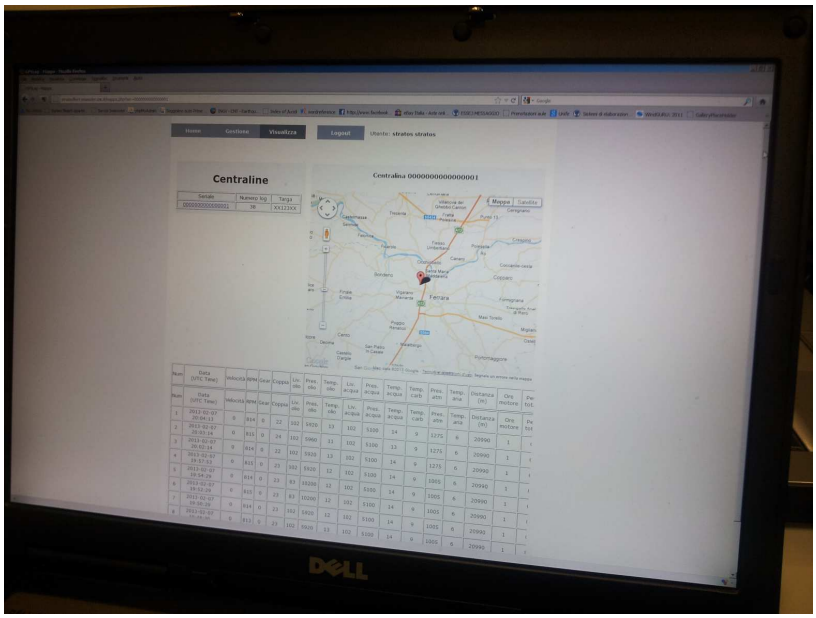

Figure 4. The WEB interface for the localization of a Google service of the data acquired from the field sensors.

4. CONCLUSION

This paper presented the results of the application of modern ISOBUS technology and self-powered energy harvesting sensors for agricultural applications. This technology has been tested to prove efficiency and reliability in a real farming environment.

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