ebbits

Enabling the business-based
Internet of Things and Services

(FP7 257852)

D2.1 Scenarios for Usage of the ebbits Platform

Published by the ebbits Consortium

Dissemination Level: Public

European Commission
Information Society and Media

SEVENTH FRAMEWORK PROGRAMME

Project co-funded by the European Commission within the 7th Framework Programme
Objective ICT-2009.1.3: Internet of Things and Enterprise environments

Document version: 1.0

Submission date: 30 November 2010

Document control page

Document file: D2.1_Scenarios_for_Usage_of_the_ebbits_Platform.doc
Document version: 1.0
Document owner: In-JeT ApS

Work package: WP2 – Requirements engineering and validation
Task: T2.1 – Scenario thinking
Deliverable type: R

Document status:
☐ approved by the document owner for internal review
☒ approved for submission to the EC

Document history:

Version	**Author(s)**	**Date**	Summary of changes made
0.1	H. Udsen (IN-JET)	2010-09-30	TOC
0.2	R. Checcozzo (COMAU), H. Udsen	2010-10-28	Text added in Sections 2-4, 6 and 8
0.3	R. Checcozzo, T.N, Madsen (TNM), J. Thestrup (IN-JET), H. Udsen	2010-11-02	TOC changed, text added in Sections 2 through 8
0.4	R. Checcozzo, T.N. Madsen, J. Glova (TUK), V. Vajda (TUK), H. Udsen	2010-11-19	New Section 2 added, Reviewer suggestions incorporated, missing sections added, use cases added
1.0	H. Udsen	2010-11-30	Final version submitted to the European Commission

Internal review history:

Reviewed by	**Date**	**Summary of comments**
Matts Ahlsén, CNET	2010-11-15	Version 0.3 approved with comments
Claudio Pastrone, ISMB	2010-11-11	Comments/suggestions for content, structure and formatting (Version 0.3)
Claudio Pastrone, ISMB	2010-11-26	Version 0.4 approved with minor comments

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1. Executive Summary

The ebbits project aims to develop architecture, technologies and processes, which allow businesses to semantically integrate the Internet of Things into mainstream enterprise systems and support interoperable real-world, online end-to-end business applications. The ebbits platform will be based on a Service-oriented Architecture, transforming every device into a service.

The ebbits platform will support interoperable business applications with context-aware processing of data separated in time and space, information and real-world events, people and workflows, optimisation using high-level business rules, end-to-end business processes or comprehensive consumer demands.

The platform will be demonstrated in end-to-end business applications featuring connectivity to and online monitoring of a product during its entire lifecycle. The project will develop, implement and demonstrate two ebbits Internet of People, Things and Services applications, one demonstrating real-time optimisation metrics, including energy savings, in manufacturing processes, the other demonstrating online traceability with enhanced information on food.

The purpose of this deliverable is to provide top-level user requirements in the form of vision scenarios of future use of the ebbits platform in the two selected areas, Automotive Manufacturing and Food Traceability.

During the initial discussions of the project objectives and the work plan the partners decided to take a slightly different approach to the Scenario Thinking method, regarding the user partners as experts in their field and building the vision scenario workshops around them, rather than involving external experts. It was agreed that the proposed business applications are sufficiently anchored in the present to make this process adaptation viable. To further benefit and expedite the requirements elicitation process it was agreed to organise combined Scenario Workshop/Focus Group sessions involving user partners as well as developer partners.

To provide the necessary background information for elicitation of relevant user requirements the existing environment of the two application areas is outlined.

1.1 The Automotive Manufacturing domain

In Section 5 the most important automotive production processes and systems and their strengths and weaknesses are described, with particular focus on energy consumption. Automated car production is generally divided into areas dedicated to specific activities, and current solutions in industrial automation can be characterised as having a centralised controls architecture. The processes of power train machining and assembly (PWT) and body welding and assembly (BWA) are explained in detail.

In car manufacturing, PWT machines and systems are specialised equipment for the production of cylinder heads, engine blocks and transmissions in metal cutting and assembly processes involving CNC machining and dedicated assembly solutions for engine and transmission components, etc.

A typical BWA line consists of an intricate collection of loaders, rollers, framers, elevators, conveyors and clamping fixtures, lending itself to the widespread use of robots for picking, loading and welding, but also requiring the involvement of human operators, who typically provide the proper fit for most of the bolt-on functional parts of the vehicle with pneumatically assisted tools.

1.1.1 Scenarios in Automotive Manufacturing

Section 6 contains two scenarios illustrating the transformations in Automotive Manufacturing of the future. Though the two workplaces may appear very different, both in terms of the final product, the machines and the processes involved, many of the problems and issues are quite similar, and the same is therefore true for the solutions.

The common scene of the two scenarios can be represented as follows:

With the enhanced possibilities provided by the innovative and pervasive monitoring systems the whole plant will become a living organism, able to configure itself in response to the internal and external environment and the physical condition of the manufacturing equipment.

Car manufacturing plants experience rapid market changes; one day the customers require more cars than the plant can produce, the next day they do not want to buy any cars. Like the weather, in the future these market fluctuations will be even more accentuated.

Car makers decided that the philosophy of production plant had to change radically, towards an extremely flexible plant able to quickly scale the production from zero to maximum plant capacity, while reducing any kind of fixed production cost.

Five years ago this sounded impossible, but innovative ICT middleware has made it possible to drastically reorganise the entire manufacturing plant and to rationalise all support systems to fully utilise production capabilities.

The *Sustainability Management* scenario:

Making certain that a plant is working at its optimum in terms of energy consumption is extremely important to maintain a high level of company integrity in the eyes of customers and institutions.

Certifying the sustainability of their production processes has become a must for all industrial manufacturers. It is important not only to obtain certifications and to avoid fines from regulatory bodies, but also to provide a healthy environment to live and to work in.

Certification inside a production plant requires continuous collection of energy consumption data. In the past such activities were performed manually, as the devices used to retrieve the data, the related communication infrastructure and the databases for data collection required a massive investment for implementation.

All the devices used in the plant are able to collect energy consumption data, and the operator does not have to retrieve information manually, the processes have been simplified and the probability of errors reduced. The devices connect to the plant network and can be easily substituted during maintenance if necessary.

The plant informatics infrastructure is able to collect from the devices all data related to process activities, energy consumption and quality indicators. The data retrieved are analysed and correlated by complex services distributed on the computer network, making it extremely simple for the operator to monitor the energy efficiency of each device, correlating indicators such as the production quantities and ultimately publish these data in the company’s sustainability reports.

The *Instantaneous Response and Predictive Maintenance* scenario:

In the plant collisions between moving mechanical parts no longer happen; this substantially reduces down-time. Moreover, the plant will alert the maintenance staff when deviations are occurring before it is too late to remedy.

The mechatronic components are able to communicate, continuously exchanging and providing information about their position and about their maintenance status. Positional information is provided by geometric software able to calculate the distance between the devices and to slow down their movement when they are too close. This eliminates completely the possibility of crashes inside the working cells.

In the maintenance office, all the data coming from each single device are decoded and interpreted to provide to the staff a work plan detailing the activities they have to perform to keep the production plant in optimum working order.

1.2 Food Traceability in the agricultural domain

In Section 7 the background of Food Traceability in the farm environment, the processing environment, the distribution environment, and the consumer environment is outlined.

Traceability is a crucial factor in ensuring that the food we eat is of high standard in terms of quality, safety, etc., whether the food is home-grown or comes from abroad, inside or outside the EU. The foundation for all food traceability systems is the unique identification and registration of all food sites or premises along the supply chain, in general involving three elements: premises identification, product identification and movement recording. Traceability systems including these elements are essential tools to support the main drivers for traceability: market access, value chain management, product differentiation, and emergency management.

In later years a rapid increase in the use of innovative ICT technologies has affected almost every area of agricultural production and distribution. Consolidation in the farm automation segment has resulted in a technical evolution towards standard TCP/IP communication and standardised data definitions, facilitating data interchange between equipment from different vendors, while consolidation in the industrial farming segment is a continuing process.

Solving the agricultural traceability challenge will involve developing the proper technologies combined with the proper data handling standards. Traceability along the food supply chain is basically the combination of two processes: *intra-enterprise traceability* and *inter-enterprise traceability*, with the ensuing questions of security, privacy and protection of proprietary business information. For this to be feasible it is necessary to adopt common data references at enterprise level to describe e.g. crop protection chemicals, implements, interventions, analysis, etc. in a consistent way. Traceability at inter-enterprise level will be inexorably linked to logistics and hence depending on having a common, precise identification of all products.

The traceability chain includes a variety of different stakeholders with great differences in ICT usage and equally great differences in the type of information they are interested in.

The players in the *farm environment* are the foodstuff suppliers, whose main interest is in ensuring that all ingredients and their composition are documented, and the farmers, who are interested in correlating the obtained output with ingredients used, breed of animals, environmental conditions, etc. to ensure maximum outcome.

The *processing environment* includes slaughterhouses and processing and packaging companies whose interests are often similar, namely to link data for the whole animal to each individual cut in order to maintain traceability.

The *distribution environment* involves wholesalers and transporters, whose main interest is the same: to demonstrate an unbroken cold chain.

The stakeholders in the *consumer environment* are retailers, for whom an important objective is to build a trust relationship with his customers, and the consumers whose main interests typically are quality and price.

1.2.1 Scenarios for Food Traceability

Section 8 contains four scenario storylines describing different parts of the traceability chain. Each scenario could be considered as an individual case, but they are all interrelated and what connects them is the need for data interchange between the different environments.

The common scene looks as follows:

The agricultural domain has now become an integrated IT platform where data floats between the different sub-domains. All cows and pigs are uniquely identified; all ingredients in feedstuff have become traceable as well as every piece of meat in the stores. Animal identification is based on RFID tags.

Data recorded in the production chain are stored as a combination of local storage on farm computers, ERP systems at the production plants (feedstuff, slaughterhouses and retail) and centralised servers at national level. The centralised servers mainly contain general information that makes it possible identify and to locate all feedstuff, animals and food products, whereas more detailed historic information related to the agricultural products is stored locally.

Recently imposed regulations on confinement and stocking densities have been instrumental in improving animal welfare.

The four storylines play out in *Feedstuff Manufacturing*, in *Pig Farming*, at the *Slaughterhouse* and at the *Consumer* end, with this common scenario:

The implementation of novel ICT systems in the agricultural domain has very significantly improved food traceability in the EU. All information is exchanged via dedicated web services, which collect the relevant data from national servers, business ERP systems and local farm computers. These exchanges are made without compromising the integrity and security of sensitive business data.

Because of the exchange of information feedstuff manufacturers and farmers can react very quickly on emerging trends in animal responses to variations in their feed. Likewise data can be exchanged between slaughterhouses and farmers to correlate individual animal development with projected consumer demands and promotion campaigns.

Livestock farming is ubiquitously monitored, and great advances have been made in predicting and preventing illnesses, thus reducing the need for medication. The ICT system is self-regulating; the widespread use of interconnected wireless sensors allows automatic adjustments in response to changes in internal and external conditions.

If so desired, the consumer has access to detailed information relating to the history and quality of purchased products, e.g. origin, animal breed, feedstuff characteristics, medical treatment, etc. This is particularly relevant for ecological and other special-brand foods.

Headline hitting food safety scares like Mad Cow Disease, dioxin-contaminated feed and adulterated olive oil are a thing of the past. The comprehensive food safety strategy within the EU keeps risks to a minimum with the help of modern food and hygiene standards drawn up to reflect the most advanced scientific knowledge. Food safety starts on the farm, and the rules apply from farm to fork, whether the food is manufactured in the EU or is imported from elsewhere in the world. And response times in case of potential risks have been substantially reduced.

1.3 Scenario interpretation and derived user requirements

Each scenario storyline represents a distinctive set of technical, security, business and socioeconomic requirements. In further support of the elicitation of these requirements, a number of use cases and corresponding use case diagrams have been developed; they are collated in the two appendices to this document.

The scenarios will provide the main framework for the iterative requirement engineering process.

2. Abbreviations and Acronyms

For the purposes of this deliverable the following abbreviations and acronyms apply:

BWA	Body welding and assembly
CGI	Compacted Graphite Iron
CNC	Computer Numerical Controlled
DCS	Distributed Control System
EPC	Electronic Product Code
ERP	Enterprise Resource Planning
GMO	Genetically Modified Organism
GS1	International association for global standards for supply and demand chains
HACCP	Hazard Analysis and Critical Control Point
HMI	Human-machine interface
IoPTS	Internet of People, Things and Services
MC	Machine Centre
OEE	Overall Equipment Effectiveness
OEEE	Overall Equipment and Energy Efficiency index
PCI	Peripheral Component Interconnect bus
PXI	Compact PCI bus
PWT	Power train (machining and assembly)
RFID	Radio Frequency Identification
S/N	Signal-to-noise ratio
TCP/IP	Transfer Control Protocol/Internet Protocol
VME	Standard ANSI/IEEE bus
VXI	Open standard bus
WP	Work Package

3. Introduction

3.1 Overview of the ebbits project

The ebbits project aims to develop architecture, technologies and processes, which allow businesses to semantically integrate the Internet of Things into mainstream enterprise systems and support interoperable real-world, online end-to-end business applications. It will provide semantic resolution to the Internet of Things and hence present a new bridge between backend enterprise applications, people, services and the physical world, using information generated by tags, sensors, and other devices and performing actions on the real world. The platform will be based on a Service-oriented Architecture (SoA), transforming every device into a service. The SoA will allow these services to semantically discover, configure, and communicate with each other.

The ebbits platform will support interoperable business applications with context-aware processing of data separated in time and space, information and real-world events (addressing tags, sensors and actuators as services), people and workflows (operator and maintenance crews), optimisation using high-level business rules (energy and cost performance criteria), end-to-end business processes (traceability, lifecycle management), or comprehensive consumer demands (product authentication, trustworthy information, and knowledge sharing).

The ebbits platform will be demonstrated in end-to-end business applications featuring connectivity to and online monitoring of a product during its entire lifecycle, i.e. from the early manufacturing stage to its end-of-life. The project will develop, implement and demonstrate two ebbits IoPTS[1] applications. The first application demonstrates real-time optimisation metrics, including energy savings, in manufacturing processes. The other demonstrates online traceability with enhanced information on food.

3.2 Purpose, context and scope of this deliverable

In order to make it possible to meet the tightened delivery schedule for this deliverable and deliverable D2.4 Initial Requirements Report, the partners decided during the initial discussions of the project objectives and the work plan to take a slightly different approach to the Scenario Thinking method. Where scenario thinking workshops, according to the prescribed IDON method, usually involve the participation of a diverse group of external experts from different parts of the domain, it was decided to regard the user partners as experts in their field and build the workshops around them. The reason for this is primarily one of time constraints: To organise two workshops with participation of the appropriate external experts was deemed impracticable within the timeframe available, particularly because deliverable D2.4 Initial requirements report, which is dependent on this deliverable, is also due to be submitted in month 3.

The partners further argued that the proposed business applications are sufficiently anchored in the present to make this process adaptation viable.

3.2.1 Purpose and Context

The purpose of this deliverable is to document and describe a set of plausible usage scenarios in 2015 and beyond for the ebbits interoperability platform in two different application areas: Automotive Manufacturing and Food Traceability.

Creating scenarios of end user behaviour and interaction with platform functionality is a very useful instrument for identifying key technological, security, and business drivers for future end user requirements. The scenarios will provide the framework for subsequent iterative requirement engineering phases.

From the scenarios and storylines, a systematic formalisation of all relevant user requirements and subsystems requirements will be derived.

The basis will be user-centric requirements originating from the ecosystems of heterogeneous stakeholders. These include functional requirements, energy requirements, business requirements and trust, privacy and security requirements. The non-functional societal requirements will include requirements related to ethics, inclusion and data protection, quality of use, professional liability, IPR issues, legal and regulatory needs, etc.

The deliverable documents the work undertaken in task T2.1 Scenario thinking and provides top-level user requirements in the form of vision scenarios of future use of the ebbits platform in the two selected domains. The next step produces technically oriented scenarios focusing on the deployment and use of the ebbits platform. These scenarios address technical questions referring to the platform and its components. The technical scenarios facilitate the formulation of the detailed requirements of task T2.2 Initial requirements specifications.

3.2.2 Scope

Vision scenarios derived from applying the IDON methodology provide coherent, comprehensive, internally consistent descriptions of plausible futures built on the imagined interaction of key trends. For the ebbits project it was decided to adapt this methodology to progress the requirement engineering work. The imposed time constraints have resulted in a slightly revised scope and the decision to regard the user partners as experts in their respective fields rather than involving external experts. To further benefit and expedite the requirements elicitation process it was agreed to organise combined Scenario Workshop/Focus Group sessions involving user partners as well as developer partners. The details of the organisation of the workshops are described in Sections 4.3.2 and 4.4.2.

4. Scenario Planning of the Future

4.1 Navigating the uncertainties of unknown futures

Making reliable decisions about future user requirements calls for a great deal of certainty - an adequate level of knowledge and confidence in our assumptions about that knowledge. But defining user requirements today is extremely complex, inasmuch as it is taking place in a fast-changing, information- and technology-driven environment. On their own, familiar planning and forecasting practices that have served us well in the past, cannot deliver the insights and answers necessary in today's world of shifting values and policies, social structures and behaviour, which increasingly challenge predictions of how the future will look.

The process of Scenario Thinking (or Scenario Planning as it is sometimes called) is widely recognised as a tool for creating user requirements specifications under uncertainty.

Scenario Thinking is not about predicting the future; neither is it about choosing the best way forward, though it is indeed a powerful and invaluable tool to this end. Its primary value lies in the development of new skills for improving the definition and planning of user requirements.

Developing and deploying these skills enables us to transcend the specific or narrowly defined solution, to go beyond short-term or one-off successes and acquire a consistency and robustness in coherent long-term user scenarios. We come to know the right questions to ask and where to look for answers to open issues; how to recognise unique opportunities and choose the best way to go.

4.2 Context scenarios

The first step in Scenario Thinking requires us to anchor ourselves securely in the present. When thinking about the future, we always do so within a context, and a starting place provides an opening array of ideas or facts, which in turn are related to some perception of a desired goal or objective for future user interaction.

As we convert this information into well-defined stories of possible future situations and our options for action in these, we unveil the inherent uncertainties that must be dealt with or overcome. An obvious fact often forgotten is that these uncertainties have been initiated by our original thinking, assumptions, omissions and commissions.

The quality and disposition of original input will strongly influence the flow of thought, handling of material and quality of output. To make the best use of scenarios, our intentions must be explicit and the issues or areas to test clearly identified.

4.2.1 What is a scenario?

We cannot with any confidence predict how the future will look because of the numerous uncertainties facing us and the potential routes technological, societal and other developments may take. Scenarios are snapshots of possible/alternative futures that help us embrace those uncertainties. Scenarios provide coherent, comprehensive, internally consistent descriptions of plausible futures, based on key trends and their envisioned interaction. Scenario thinking essentially requires you to think from the outside in, taking you through a process that starts with creating context for the unknown.

4.2.2 What is the purpose?

The purpose of Scenario Thinking is to challenge the preconceived notions we may have of the future, allowing us to revise or revisit our accustomed approach. The process is intended to open up the way you think about the future. Scenarios help identify threats, recognise opportunities and make choices about strategically important issues. A scenario illuminates the possible, what might be. It prods you to do something slightly counterintuitive; to go beyond the known into the unknown, outside your areas of expertise.

4.2.3 How to use scenarios

As you read the scenarios, think about how you might answer each of these questions:

- Is this even remotely possible?
- Would the world be a better place in this scenario?
- If you were a user in this scenario, what would you be doing differently?
- If you knew for sure that this scenario was to come true, what would you as a user do now?

In essence the Scenario Thinking process is designed to arrive at several parallel, co-existing hypotheses about the future. These variant hypotheses are given concrete form, and users can visualise them because they are embedded in a story or a scenario. In turn this means that the same person can look at the evidence through different sets of glasses and see things in a different perspective.

4.3 Development of scenarios in Automotive Manufacturing

4.3.1 The hosting institution

COMAU S.p.A.[2] is a global supplier of industrial automation systems and services, mainly for the automotive manufacturing sector. Over the years COMAU has broadened its presence all over the world, partnering the automotive industry in developing solutions for all industrial production programmes. The continuous improvement of products, processes and services, through the application of advanced innovative technological solutions, contributes to customer competitive advantage. COMAU is organised in three Business Units: Body Welding & Assembly, Power Train Machining & Assembly and Robotics & Service.

Through their integrated global organisation COMAU offers full services from product engineering to maintenance activities, operating in the continuously evolving automotive market, in the areas of Sheet Metal Dies, Power Train Machining & Assembly, Body Welding & Assembly Systems, Robotics, Aerospace Production Systems and Maintenance & Engineering Services. In addition, COMAU offers system integration and complete engineering solutions, from product development to manufacturing, from assistance in the production start-up phase to equipment servicing and complete plant maintenance activities.

COMAU automation systems are designed to make manufacturing processes simple, lean and cost-effective. Continuous R&D activities result in state-of-the-art engineering technology and factory-floor tested hardware and software, all the while supporting customers in finding the single or global solution to all manufacturing requirements.

The company's systems and machinery are used by all major automotive manufacturers at facilities in Europe, America and Asia, and their industrial automation solutions are applied by large and small companies all over the world, operating in a vast range of different sectors.

COMAU has been involved in many other European Research Projects.

4.3.2 Organisation of workshop for Automotive Manufacturing

A combined Vision Scenario/Focus Group workshop for Automotive Manufacturing took place in Torino, Italy, on October 19, 2010. The workshop was hosted by COMAU and moderated by IN-JET.

The following persons from COMAU participated as expert User Partners:

Fulvio Rusinà (R&D Director), Domenico Govoni (PWT Controls Engineering Director), Angelo Fonte (PWT Controls Engineering Manager), Paolo Beltramo (PWT Controls Engineer), Michele Putero (PWT R&D funded projects), Francesco Matergia (BWA Controls Engineering Director Europe), Guido

Rumiano (BWA Advanced Engineering Controls Manager), Giacomo Gandini (BWA Advanced Engineering Engineer), Roberto Checcozzo (BWA R&D funded projects), Antonio Pastore (ICT Director).

As Developer Partners and stakeholders the following persons participated:

Amro Al-Akkad (Fraunhofer), Peter Kostelnik (TUK), Ferry Pramudianto (Fraunhofer), Maurizio Spirito (ISMB).

The workshop covered two main manufacturing areas: Power Train Machining & Assembly (PWT) and Body Welding & Assembly (BWA). For each area presentations describing the business and the controls architecture were given, during and after which the participants had the opportunity to ask and answer questions.

The User Partners also shared their visions and ideas for the future use of the ebbits platform, thus providing the basis for the scenarios in Section 6. These visions combined with the conclusions from the Q&A sessions provided the Developer Partners with the foundation for eliciting the technical requirements for D2.4 Initial Requirements Report.

4.3.3 Selection of application area and time horizon

With a time horizon of 2015 and beyond, one of the main areas of development will unquestionably be related to the improvement of the eco-sustainability of the car manufacturing plant. One of the major drivers for the EU community is increased efficiency of energy usage and subsequent reduction of carbon dioxide emission, as stated in the Kyoto protocol which has been signed and ratified by all EU member countries.

The area of development identified for the ebbits project goes a step further than just monitoring and collating energy consumption data. The project also aims to provide a platform able to correlate the detailed device activity data with the energy consumption. The analysis of such data will provide important indications as to the correct functioning of the machine, detailed information on energy consumption and predictions about possible breakdown of malfunctioning devices and machinery.

Some of the main areas to be considered are the following:

- Collection of data related to energy consumption
- Collection of data regarding the status of the machine and the position of the devices
- Correlation of consumption data with machine status and position
- Generation of reports based on real-time data for managerial and operational purposes.

4.4 Development of scenarios in Food Traceability

4.4.1 The hosting institution

TNM A/S[3] has a high level of knowledge and experience in computer science, statistics, management based on mathematical methods/models and IT deployment and operations. The use of this knowledge is specifically focused on the agricultural sector. Through close cooperation with other companies, trade associations and universities TNM A/S operates as a farmer's ICT department and the Danish agricultural sector's guarantee of IT security through the TNM group's various businesses. TNM is competent in delivering an optimal ICT solution for existing farming machines and for new farm buildings. Through close collaboration with suppliers of farm mechanisation, agricultural trade associations and universities, TNM has developed skills and competence in interoperability of farm systems. Special technology areas of high expertise include: Security, wireless networks and bridges, and IP remote control.

TNM A/S is co-owned by the DLG group, the largest agricultural supplier in Denmark. World-wide the DLG Group has subsidiaries in 27 countries and is considered market leader in northern Europe.

4.4.2 Organisation of workshop for Food Traceability

A combined Vision Scenario/Focus Group workshop for Food Traceability took place in Copenhagen, Denmark, on October 1, 2010. The workshop was hosted by TNM and moderated by IN-JET.

Expert external participants were Jens Ole Christensen of DLG, representing the feedstuff manufacturing business, and Claus Fabricius of Logisys, providing specialised knowledge pertaining to slaughterhouses and food retailers.

In addition, Thomas N. Madsen and Michael Jacobsen from TNM participated as expert User Partners.

As Developer Partners and stakeholders, Ferry Pramudianto and Andreas Zimmermann of Fraunhofer and Peter Kostelnik of TUK participated.

The workshop covered four main topics: feedstuff manufacturing, livestock farming, slaughtering and retailing. For each area presentations describing the business and the controls architecture were given, during and after which the participants had the opportunity to ask and answer questions.

With particular emphasis on traceability the external experts and User Partners also shared their visions for the future use of the ebbits platform, thus providing the basis for the scenarios in Section 8. As for the Automotive Manufacturing workshop, these visions together with the Q&A sessions gave the Developer Partners the foundation for eliciting the technical requirements for D2.4 Initial Requirements Report.

4.4.3 Selection of application area and time horizon

The decision to select a time horizon of 2015 was considered suitable in the light of the project's firm anchoring in the present. The primary characteristic of the envisioned end-to-end business application is online traceability. In addition, the application will make it possible to collect and distribute many different types of information, which will serve equally different purposes for the diverse group of stakeholders.

5. The Automotive Manufacturing Domain

Section 5.1 contains an overall description of the most important processes in car manufacturing.

User partner COMAU possesses special expertise in power train machining and assembly processes and body welding and assembly processes. These processes and related systems and equipment are described in more detail in Section 5.1.1 and Section 5.1.2 and they will also be the focal points in the future scenarios in Section 6.

5.1 Automotive production processes and systems

Automated car production is generally divided in areas dedicated to specific activities. On the whole car makers retain in-house only part of the production process, as the complete car manufacturing process requires large investments and a great deal of space and manpower.

The majority of car manufacturers concentrate their efforts on the following parts of the manufacturing process:

- Power train plant: where engines are machined and assembled
- Body welding (also called 'body in white shop'): where the body of the car is assembled and welded
- Painting shop: where the body in white is prepared for painting and finally painted and cocked
- Final Assembly: where the painted body is fitted with engine, suspension, trim and all the other parts.

Modern day Industrial Automation Systems control highly complex networks of high performance machine systems executing multi-parameter control of variables like precision motion, force, temperature, flow rate, pressure, etc. Not only is the control and monitoring of all these parameters important, transfer of control signals to and from these Distributed Control Systems to central controllers must be seamless, which makes networking a major component in successful implementation of these open systems. The reason why networking capabilities are needed in industrial Automation systems is threefold:

- To provide connectivity to different machines
- To enable data sharing and gathering
- To define a flexible solution facilitating integration of future advances in technology.

Industrial Automation is commonplace in most conventional manufacturing units. There is increasing pressure that these complex controls with extremely high throughputs and miniaturisation are implemented with cost-effective electronics and robust software. Though high-end machines for advanced industries are built in relatively smaller volumes compared to consumer goods, the need to curtail capital expense on them is borne out of the need for cheaper end products, and hence the need for each successive generation to perform at higher levels and lower cost. Combinations of high-speed data bus and fast embedded processors enable new cost-effective, high-performance architectures for advanced machine design and other real-time automation tasks. The industrial adoption of components originally designed for higher volume consumer applications are a certainty for the next generation of industrial controls.

The main weaknesses of present manufacturing systems, which highly affect overall efficiency and reduce competitiveness, basically refer to the following aspects:

- Process integration: limited integration among the processes involved in the engineering and management of the plants
- Flexibility: inadequate flexibility of the production plant, with limited capability for handling variations in product mix and volumes

- Scalability and reconfigurability: production systems are not designed to be easily reconfigurable
- Manufacturing efficiency: the monitoring of productivity is affected by low diagnostics capacity; there are usually no efficient instruments to detect engineering errors and to prevent installation problems, as well as efficient data logging to enable predictive maintenance
- Ramp-up time: the time to reach full production capacity is often too long and therefore too costly.

Current solutions in Industrial Automation Controls can be characterised as Centralised Controls Architecture. Backplane Based controllers were considered to be natural choices for the designers of yesterday as it was assumed that they could provide the high communication speeds needed for Industrial processes like synchronising motion, synchronising images and data acquisition. The rack-mounted backplane which is the standard implementation for most Industrial and Laboratory Automation controllers uses bus solutions like VME, VXI, and PXI in addition to proprietary buses like Modbus. In recent times PCI buses have gained popularity in this market segment owing to the penetration of Windows based PCs.

In the conventional architecture, all sensors, motors, digital inputs and outputs and analogue signals are cabled from the point of use to converge at the centralised controllers with individual backplane cards designed to handle each specialised function. All signals are brought to the physical location of the system controller using multi-wire cable bundles.

Machine Systems typically use several specialised backplanes to implement different control functions. Bus to bus communication between various subsystems is often through traditional RS-232/422/485 serial communication channels or through bus converters. This centralised approach limits reliability and configurability as hundreds of conductors are required to route signals to the central control chassis.

Overall, this traditional approach is cumbersome, relatively large and more expensive. Another big problem is the software used for controllers. Due to the lack of standard interfaces, different vendors have different software approaches for the development of various subsystems, and to integrate them has proved to be expensive and time-consuming.

To avoid the use of a centralised backplane based system, it is important to localise control of devices performing similar functions. This Distributed Control System (DCS) architecture uses some form of serial or parallel cable to link already digitised information from point of use. In DCS analogue signals are quickly digitised, and functions that do not need to be centrally supervised are localised. The advantages of using DCS are as follows:

- Greater Signal integrity (S/N) by reducing the distance that analogue signals must travel before they are digitised, important in applications where signal-to-noise ratio maximisation is demanded
- Cabling can be simplified and functional sub-systems can be modularised. These sub-systems can be then plugged into bigger and more complex networks hence simplifying system configuration
- Remote monitoring of signals or control functions over a local area or public network is simpler with DCS architecture as it is inherently packet driven.

Many distributed control schemes have been developed and implemented for industrial applications over the past three decades. The oldest ones were based on Fieldbus and its derivatives with newer technologies like DeviceNet, Can or Profibus taking over. These buses had data transfer rates in the range of only a few MB/s which was far lower than backplane buses like VME or PCI. This hampered the adoption of DCS-based architecture by a majority of system designers even though distributed control systems were far more efficient compared to backplane based industrial automation systems.

5.1.1 Power train and engine assembly (PWT)

Power train machining activities differ depending on type of engine.

The process for an aluminium basement for a 16V engine includes the following operations:

- Cubing machining with Machine Centre (MC)
- Machining with MC
- Intermediate Washing Machine
- Intermediate Leak Test Machine
- Guides and Seats Press Machine
- Machining with MC
- Intermediate Washing Machine
- Caps Assembly machine
- Machining with MC
- Final Washing Machine
- Press plugs Machine
- Final Leak Test Machine
- Visual check.

The process for a cast-iron basement for a four-cylinder engine includes the following operations:

- Cubing machining with MC
- Machining with MC
- Intermediate Washing Machine
- Intermediate Leak Test Machine
- Bedplate assembly machine
- Machining with MC
- Cylinder bore and crank bore honing machine
- Final Washing Machine
- Press plugs Machine
- Final Leak Test Machine
- Visual check
- Cylinder bore and crank bore measuring machine.

PWT machines and systems are specialised equipment for the production of cylinder heads, engine blocks and transmissions, though they are also used in other fields, e.g. the aerospace or power generation industry.

Machining

Machining involves different types of products (heads, blocks, crankshafts, transmissions), sizes and materials (aluminium, cast iron, CGI, etc.). Architectures and processes must meet demanding requirements in flexibility and production scalability. Examples of metal cutting systems are shown in Figure 1.

PWT machines are also deployed to develop transfer lines or to integrate these into hybrid solutions.

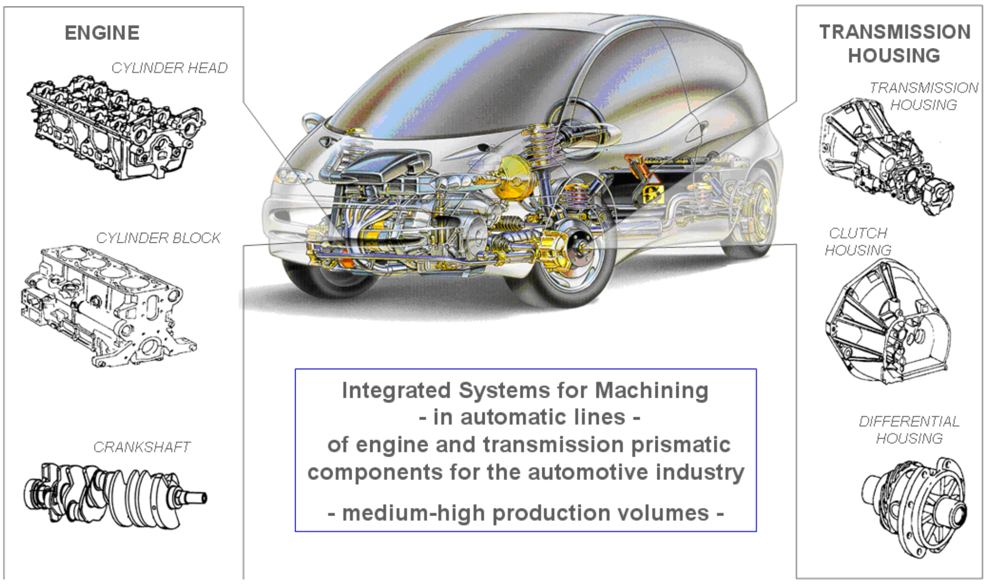


Figure 1 – Automotive Systems: Metal cutting

CNC Machining

CNC Machining Centres, as depicted in Figure 2, offer modular configuration to handle different market requirements in terms of flexibility and production scalability, ensuring high productivity, excellent performance and low lifecycle costs.

Figure 2 – SmartDrive CNC Machining Centre

A typical layout of an automatic metal cutting line with a number of different CNC machining centres is illustrated in Figure 3.

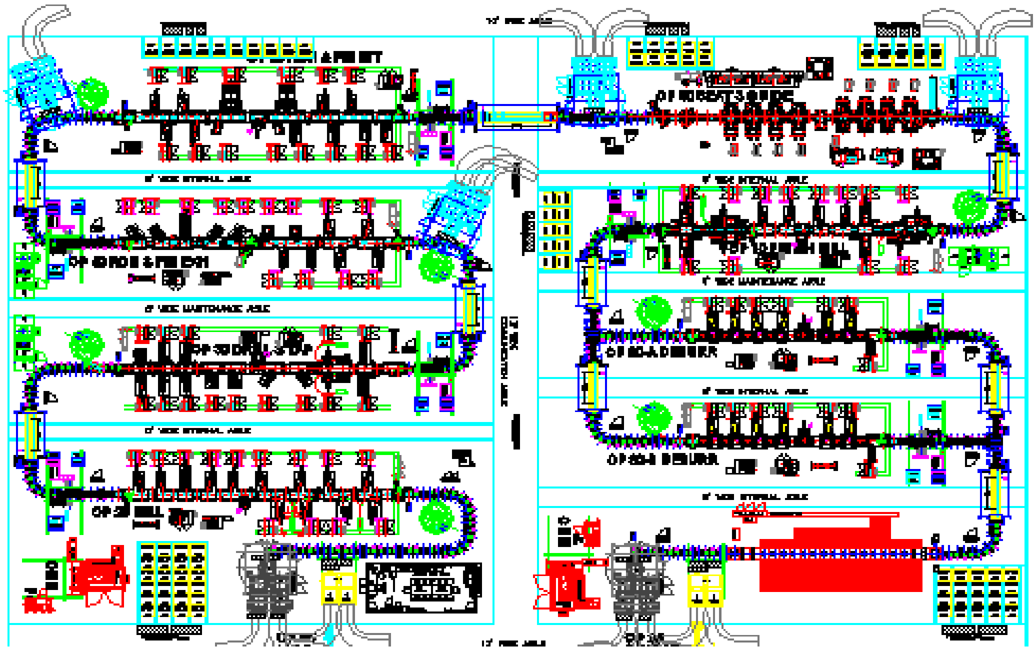


Figure 3 – Automatic metal cutting line layout

Assembly Modular Solutions

Typical assembly systems are based on standard modular solutions for the assembly of engines (cylinder head, short block, long block), transmissions (automatic, manual, Continuously Variable Transmission) and components, as well as ancillaries – valve seats and guides, plugs, caps within the metal cutting lines. Examples of assembly systems for engine and transmission components are featured in Figure 4.

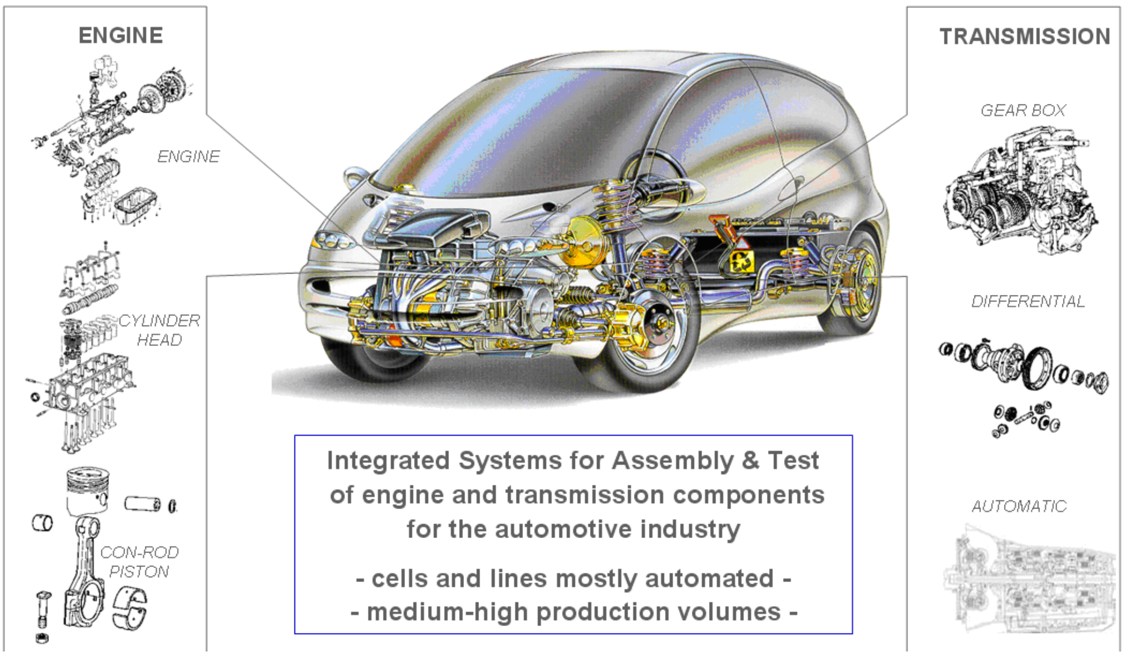


Figure 4 – Automotive systems: Assembly and test

Assembly modules can be designed for multiple assembly operations through interchangeable tooling and automatic tool change. Cells based on a standard Cartesian structure manage all assembly operations, with different specific tools for specific tasks in cylinder head and engine assembly. A complete production line for any particular component integrates a dedicated transportation system. A typical layout is shown in Figure 5.

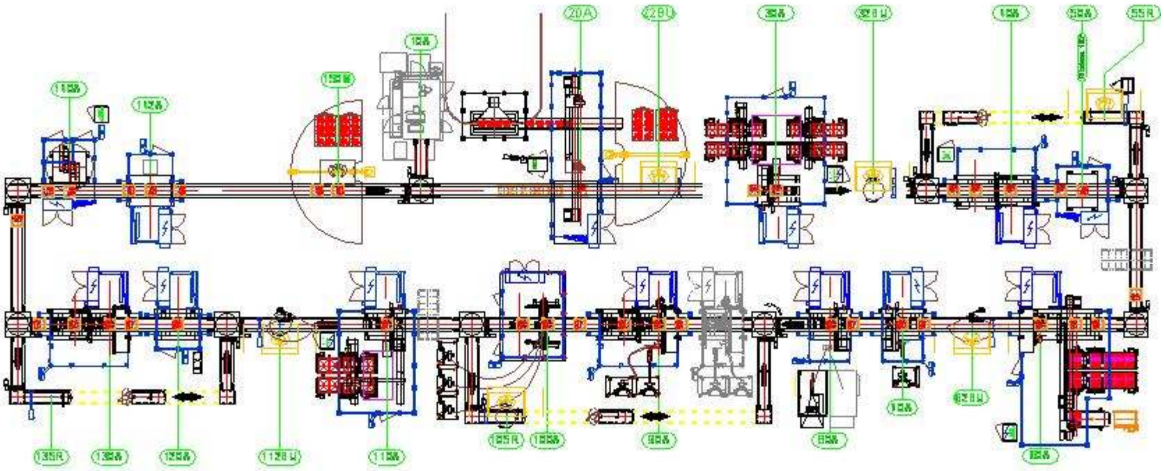


Figure 5 – Automatic assembly line layout

5.1.2 Body welding and assembly (BWA)

The floor panel is the largest body component to which a multitude of panels and braces will subsequently be either welded or bolted. As it moves down the assembly line, held in place by clamping fixtures, the shell of the vehicle is built. First, the left and right quarter panels are robotically disengaged from pre-staged shipping containers and placed onto the floor panel, where they are stabilised with geometric fixtures and welded.

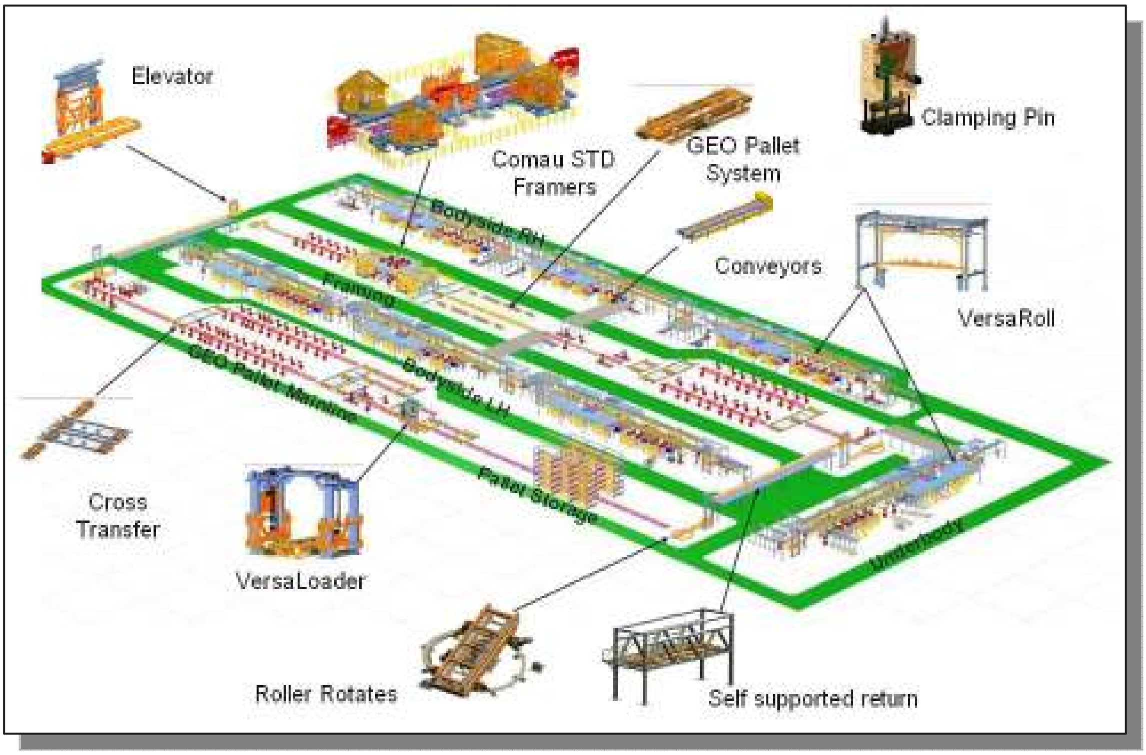


Figure 6 – Body welding and assembly line

The front and rear door pillars, roof, and body side panels are assembled in the same fashion. The shell of the automobile assembled in this section of the process lends itself to the use of robots because articulating arms can easily introduce various component braces and panels to the floor panel and perform a high number of welding operations in a timeframe and with a degree of accuracy no human workers could ever approach. Robots can pick and load roof panels and place them precisely in the proper position for welding, assisted by vision devices.

The body is built up on a separate assembly line from the chassis. Robots once again perform most of the welding on the various panels, but human operators are necessary to bolt the parts together. During welding, component pieces are held securely in a jig while welding operations are performed.

As the body moves from the isolated welding area of the assembly line, subsequent body components including fully assembled doors, deck lids, hood panel, fenders, trunk lid, and bumper reinforcements are installed. Although robots help workers place these components onto the body shell, the workers provide the proper fit for most of the bolt-on functional parts using pneumatically assisted tools.

The controls architecture used in Body Welding and Assembly is continuously changing and evolving, from a centralised controls architecture in the direction of a fully distributed controls architecture. In the near future the architecture can be expected to be as shown in the figure below.

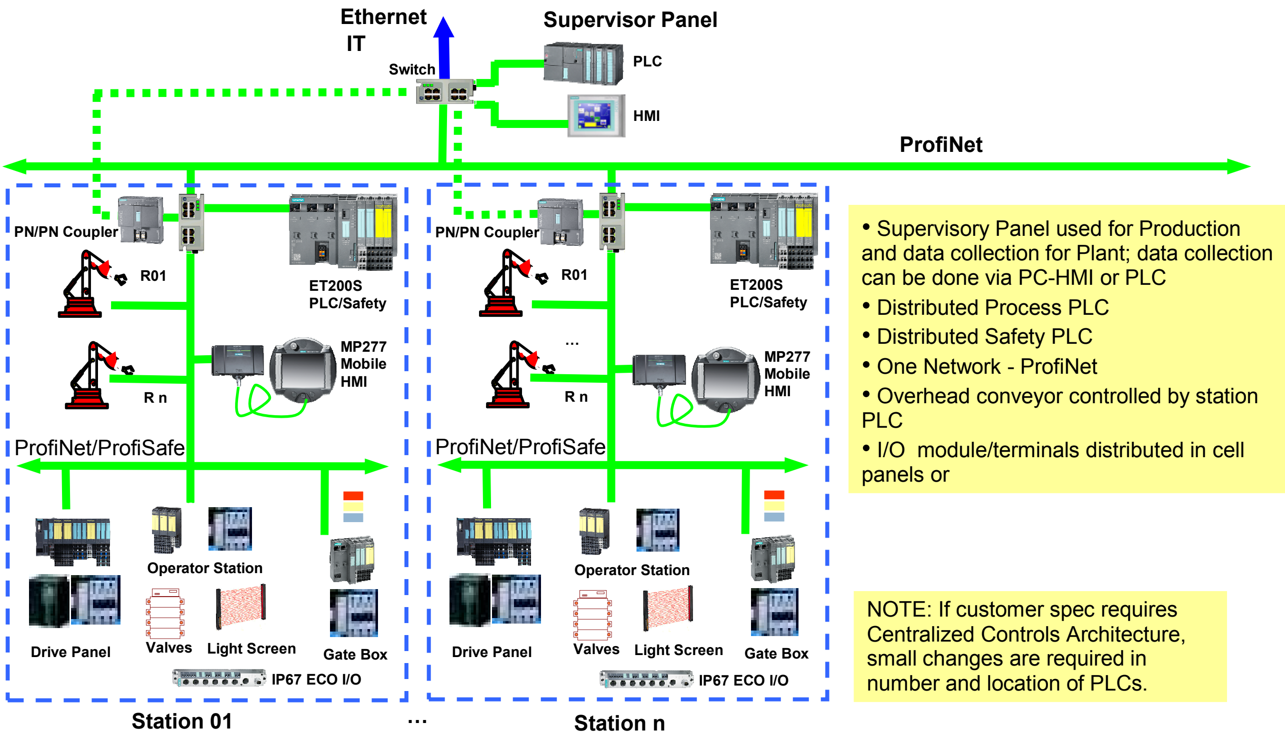


Figure 7 – Fully distributed Controls architecture

Contemporary body welding and assembly is characterised by advanced production systems for vehicle full body, body components manufacturing and complete turnkey body shops with focus on cost-effective low, medium and high volume body welding and assembly systems.

BWA solutions are designed to offer maximum flexibility of the production plant. New product lines introduced on the market typically have the following distinctive characteristics:

- Self-contained large sub-assembly manufacturing machines
- High-speed part transfer systems
- Selectable and flexible station processes
- Capable of 4+1 model random or infinite model batch production.

These novel solutions offer excellent performance in the automated plant, featuring

- High flexibility, by way of modularity of all devices and structure
- Low time-to-market, accomplished by simple and rapid assembly operations
- Better process quality, through innovative positioning of robots, allowing all-points access
- Decreased cycle times via high-speed transportation systems
- Lower running costs, operators can access from under the structures for maintenance.

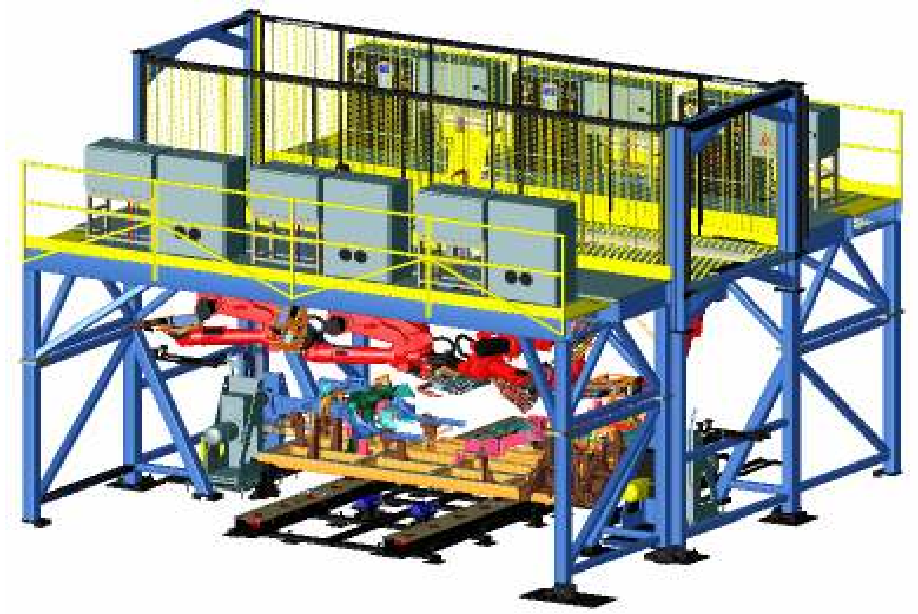


Figure 8 – Access from below

The solutions are characterised by the modularity of the structure to be assembled in the production plant, requiring less space to perform the same operation. Moreover, the modular design of the production station allows rapid design of the production flow of the plant, without the need for any particular custom design.

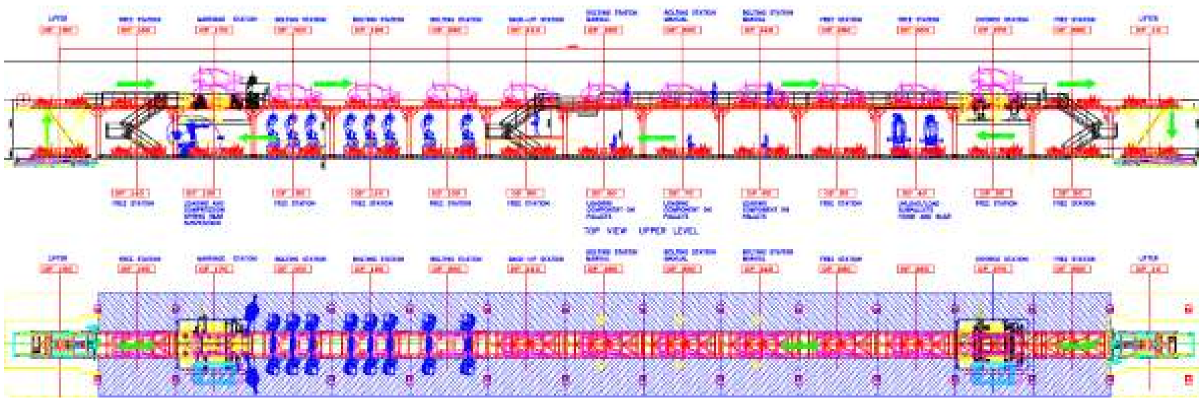


Figure 9 Body welding and assembly line

5.2 Energy considerations

The industrial sector uses more energy than any other end use sector, currently consuming about half of the world's total delivered energy. Energy is consumed in the industrial sector by a diverse group of industries and for a wide range of activities, such as processing and assembly, space conditioning, and lighting.

Though significant improvements have been made in car manufacturing in recent years, it is still a highly energy-consuming business.

In some cases, because of the high output (which can be one car per minute) and long start-up time, production lines are running idle over weekends, because operators are worried that the intricate and interconnected production systems will be out of whack if stopped and restarted.

Some car manufacturing plants still use old-fashioned automatic lines, the so-called 'brown-field' plants. These facilities were engineered with no particular attention to energy efficiency, as the drivers of the production were merely the cost per part produced, when these facilities were built. Several automatic lines were developed around the concept of special machines and transfer lines, where the workpiece is moved from one station to the next by means of a transfer line. At each stop along the line a single operation is executed on the workpiece. Retooling operations on these conventional automatic lines are extremely difficult as the flexibility is close to zero.

More modern automatic plants, so-called 'green-field' facilities, are extensively using machining centres fed by means of pick-up or other flexible transportation systems. This process takes advantage of the capability of the machining centres to execute several activities on the workpiece, because the cutting devices can be exchanged. Thanks to multi-axis electrospindles and supporting tables metal cutting operations can be performed on virtually any part of the workpiece. On these machines retooling operations are extremely easy, and moreover they can be performed as an operation known as 'green-fitting', a set of particular operations carried out on the machine in order to drastically increase its energy efficiency.

Though energy consumption data are very important, not all machines can provide useful information on the power used to perform their job. The cost to perform an in-depth continuous monitoring of tension and current on the machines is still too high because of the cost of the electronic devices, the cabling and the software that must be installed to perform such operations. With the ebbits platform, exploiting the middleware that allows the use of the Ethernet infrastructure for communication of energy related data, this obstacle could easily be overcome.

6. Scenarios in Automotive Manufacturing

This section contains two scenarios illustrating the transformations in automotive manufacturing of the future. The characters in the storylines are two employees working in a Body Welding department and a Power Train department, respectively. Though the two workplaces may appear very different, both in terms of the final product, the machines and the processes involved, many of the problems and issues are quite similar, and the same is therefore true for the solutions.

In fact, the personnel working in different areas of car manufacturing used to talk about common problems, mainly related to controls architecture, communication infrastructure and monitoring systems. Now they are also talking about the common problems of energy efficiency and carbon dioxide emission.

Consequently, while different topics have been addressed in the two storylines, the subject matter in one scenario could equally well be representative of a common problem in the other setting.

6.1 Scenario scene in Automotive Manufacturing

With the enhanced possibilities provided by the innovative and pervasive monitoring systems the whole plant will become a living organism, able to configure itself in response to the internal and external environment and the physical condition of the manufacturing equipment.

Car manufacturing plants experience rapid market changes; one day the customers require more cars than the plant can produce, the next day they do not want to buy any cars. Like the weather, in the future these market fluctuations will be even more accentuated.

Car makers decided that the philosophy of production plant had to change radically, towards an extremely flexible plant able to quickly scale the production from zero to maximum plant capacity, while reducing any kind of fixed production cost.

Five years ago this sounded impossible, but innovative ICT middleware has made it possible to drastically reorganise the entire manufacturing plant and to rationalise all support systems to fully utilise production capabilities.

6.2 Sustainability management scenario

Making certain that a plant is working at its optimum in terms of energy consumption is extremely important to maintain a high level of company integrity in the eyes of customers and institutions.

Certifying the sustainability of their production processes has become a must for all industrial manufacturers. It is important not only to obtain certifications and to avoid fines from regulatory bodies, but also to provide a healthy environment to live and to work in.

Certification inside a production plant requires continuous collection of energy consumption data. In the past such activities were performed manually, as the devices used to retrieve the data, the related communication infrastructure and the databases for data collection required a massive investment for implementation.

All the devices used in the plant are able to collect energy consumption data, and the operator does not have to retrieve information manually, the processes have been simplified and the probability of errors reduced. The devices connect to the plant network and can be easily substituted during maintenance if necessary.

The plant informatics infrastructure is able to collect from the devices all data related to process activities, energy consumption and quality indicators. The data retrieved are analysed and correlated by complex services distributed on the computer network, making it extremely simple for the operator to monitor the energy efficiency of each device, correlating indicators such as the production quantities and ultimately publish these data in the company's sustainability reports.

6.2.1 Scenario storyline

Mario, an employee supervising the Body Welding and Assembly department of a car manufacturing plant in Italy, has experienced the complete transition from a manufacturing plant based on legacy controls architecture and energy-greedy systems towards highly flexible, efficient processes monitored and controlled by novel networked solutions.

In the past, to ensure that all production lines were ready to run, compressed air was continuously provided to the plant, also during weekends, because any shortage could change the position of the mechanical actuators, requiring human intervention to restore the correct physical start position of the plant, the only one recognised by the automatic controls to begin the production cycle. Any incorrect position of the machine might lead to dangerous crashes of the moving devices, such as robots, clamps, and slides.

The informatics infrastructure has helped eliminating entirely any kind of inefficient energy transportation system, e.g. compressed air, and with ubiquitous use of pervasive monitoring and control systems it is now possible to minimise energy consumption. The elimination of compressed air provided several positive effects. Compressed air was the most inefficient energy transportation system in the old set-up, as the losses on the line were at least half of the total energy produced. Now innovative middleware maintains the efficiency of the hardware to obtain the same performance of the pneumatic actuators.

A few years ago the EU decided that one of the strategic objectives was to reduce drastically the global emission of CO_2. So Mario's company decided to implement a stringent strategy to use the minimal amount of energy. In addition to elimination of compressed air the company has developed production lines able to consume more energy when market requests are high, like a "turbo boost", and eliminate any kind of energy consumption or waste when market requests are low, to the extent of complete hibernation of the plant like bears in winter.

Mario still remembers vividly Monday mornings in the past, when the whole plant was still a mess because no one knew exactly what to do, and all documents were paper-based and distributed by hand. So every Monday morning Mario had to show up for work at 4 in the morning to have enough time to start up the entire plant.

The mechatronic[1] components are equipped with sensors able to collect and interpret in real time information on energy consumption, trajectories, sound levels etc. This information, properly correlated, can predict the presence of a possible problem in a device and notify the plant informatics infrastructure. So Mario does not have to check each singular device on the manufacturing line, and the daily work plan for each line is provided by the informatics infrastructure. He can come in Monday morning at 6 like all the other employees, because he knows that the plant never will have any crashes and it will start functioning perfectly from the very first minute of the production shift.

These days Mario works in a friendly environment, continuously connected with his peers in the plant through easy-to-use handheld devices allowing him to check the state of the whole plant. He no longer has to stay on the line to anticipate faults, providing he carries his teach pendant[2] with him.

Actually it makes no difference whether he accesses the information from his handheld device or from any PC, mobile phone, or any application hosting device, as all the information is published by a web server, and today almost all devices are able to browse web pages.

[1] Mechatronics is the synergistic combination of mechanical engineering, electronic engineering, computer engineering, control engineering and systems design engineering

[2] Devices equipped with switches and dials used to control a robot's movements to and from desired points within a determined space

Mario prefers to use his personal wireless teach pendant because it has embedded safety functionalities, such as emergency stop button and live-man switch. The pendant also lets him move the robots on the automatic line directly, just like in the old days.

6.3 Instantaneous response and predictive maintenance scenario

In the plant collisions between moving mechanical parts no longer happen; this substantially reduces down-time. Moreover, the plant will alert the maintenance staff when deviations are occurring before it is too late to remedy.

The mechatronic components are able to communicate, continuously exchanging and providing information about their position and about their maintenance status. Positional information is provided by geometric software able to calculate the distance between the devices and to slow down their movement when they are too close. This eliminates completely the possibility of crashes inside the working cells.

In the maintenance office, all the data coming from each single device are decoded and interpreted to provide to the staff a work plan detailing the activities they have to perform to keep the production plant in optimum working order.

6.3.1 Scenario storyline

Alberto works in the Power Train Maintenance department of Spanish car manufacturer AutoVerde, and his main responsibility is to ensure the smooth running of all production lines whatever the prevailing circumstances.

Taking care of an automatic plant used to be an extremely difficult task. Employees in the plant needed years to learn how to become aware of anomalies that might cause production shut-downs. In some cases employees, like Alberto's former boss, developed the ability to "listen" to the sound of the machine to perceive changes in the repetitive cycle and almost prophetically forecast potentially disastrous situations.

The all-encompassing monitoring system detects any kind of internal and external variation in the production environment. Externally it detects financial fluctuations, providing information on the long-term strategy to be adopted; it detects the logistic situation, adapting the tactical production plan. Inside the plant, it detects the production flow status, faults on the machines and manages anomalous situations alerting the maintenance crew to intervene.

In the past Alberto had to wait for the decision of senior management in order to change the production strategy, and those decisions were forthcoming only after several weeks of data collection, analysis and discussion. Thanks to the new infrastructure, the data are retrieved immediately from both the external environment and internal environment, the data flow is real-time in the system, and the decisions are immediate subsequent to any change in the conditions.

A control system has been implemented which is capable of reacting to internal and external indicators in order to speed up or slow down motors and actuator movement. This way the plant only consumes energy when required. Previously this was impossible because at the higher level the control system was not able to analyse globally the plant status to properly control the overall production speed, and at lower level there was no devices able to synchronise robots and moving devices to prevent crashes when they changed speed. It was extremely hard to reduce speed of the objects because each of them reacted in a different manner, driving the machine to a sure crash.

As AutoVerde wanted to be certified as a green industry, they replaced all the devices used in the plant with new ones capable of collecting energy consumption data, so the operators no longer have to retrieve this information manually, the process is simplified and the probability of errors substantially reduced. The devices connect uniquely to the plant network, simplifying the substitution of devices during maintenance operations.

The plant informatics infrastructure collects all device data related to the process activities, to the energy consumption and to the quality indicators. The data retrieved are analysed and correlated by complex services distributed on the network, and it is extremely simple for the operator to monitor the energy efficiency of each device, correlating indicators such as the production quantity and in the end to publish these data in the company sustainability reports.

So AutoVerde is now able to provide consolidated data on the energy consumption of the production plant, and what's more, it has a new set of indicators that go beyond the classical OEE (overall equipment effectiveness), because they also consider the energy parameters. Those new indicators, the OEEE, provide valuable information on what strategies to implement in the company in order to conserve resources and harmonise energy consumption with production activities.

6.4 Scenario use case diagrams

Use cases in software engineering and systems engineering are descriptions of a system's behaviour as it responds to a request that originates from outside of that system. In other words, a use case describes "who" can do "what" with the system in question. The use case technique is used to capture a system's behavioural requirements by detailing scenario-driven threads through the functional requirements.

Use case diagrams are a type of behavioural diagram defined by and created from a use case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases.

In Appendix 1 is shown four high-level use case diagrams, three from the Sustainability management storyline in Section 6.2.1 and one from the Instantaneous response and predictive maintenance storyline in Section 6.3.1.

These use cases will be further developed and utilised for elicitation of user requirements in the requirements engineering process; they can also work as basis for the work undertaken in WP3 pertaining to the description of enterprise and management processes in the domain.

7. Food Traceability in the Agricultural Domain

7.1 Background of Food Traceability

The concern of the European Union is to make sure that the food we eat is of the same high standard for all its citizens, whether the food is home-grown or comes from another country, inside or outside the EU. Traceability in the food sector is one of the keystones in obtaining this goal, and the rapid technological development in the business has opened a variety of new possibilities for obtaining and exchanging data.

Core to all food traceability systems is the unique identification and registration of all food sites or premises along the supply chain. Locating all premises is the first step to developing a series of management tools and solutions for appropriate use by both industry and government to support informed decision making. Full chain traceability involves in general three elements: premises identification, product identification and movement recording that are consistently linked through trace-back/trace-forward systems developed at each step in the food chain, from production through processing, distribution, retail and to the consumer.

In the past 10-15 years, the use of innovative ICT technologies has seen a rapid increase throughout mainstream Europe in almost every area of agricultural production and distribution. In the industry of farm automation extensive consolidation has taken place, resulting in fewer but much larger companies with more powerful R&D departments. This has encouraged a technical evolution towards standard TCP/IP communication on all farm equipment and standardised data definitions, which allow data interchange between equipment from different vendors (feeding systems, ventilation systems, management systems, etc.). This means that the technological platform in state-of-the-art farm environment is at a level that allows for the necessary data interchange required in a full traceability model upstream and downstream.

New technologies such as high-frequency RFID tags have made it possible to identify individual animals like slaughter pigs and cattle in the production. This is essential for food traceability, but for the farmer the choice of using RFID tags (e.g. in slaughter pig production) depends on the economic outcome of using this technology. In other words, he expects immediate payback for his investment; otherwise he will not use the technology. The challenge here is that the benefit from using individual identification of animals is the sum total of effects all the way through the production and distribution chain from feed production, through growing the animals on the farm to slaughtering and distributing and finally ending up in the hands of the consumer.

In the distribution environment identification and tracking has been common in later years. But the tracking is typically based on bar codes that only identify the *type* of product and the supplier. Various endeavours are presently undertaken to enhance standards of identification and tracking in the food distribution sector. In the European project TRACE[4] the situation is clarified in the following way:

Current traceability systems address the logistic traceability of products in such a way that each link requires keeping records of preceding and succeeding links. The Concerted Action FOODTRACE is attempting to develop a traceability framework for the entire food chain and is addressing key elements of the White Paper on Food Safety. However, little work has been focused on developing systems that can be used for verifying the origin of food. TRACE will establish what type of technical information, collected at critical steps along the entire production chain, is essential for substantiating claims of authenticity. Specifically it will incorporate analytical specifications into supply chain information systems to produce a traceability infrastructure that will more easily allow verification of origin. It is proposed that all traceability information, i.e. specifications, analytical and non-analytical, should be made available digitally in order to make this information readily accessible to stakeholders.
Each link (partner) in the supply chain should be able to provide and use this information. Preferably, this information, including details of the product specification, should be linked to a

(globally) unique number, and the number should be affixed to the product using a label, a bar code, or an electronic tag.

In other words, solving the agricultural traceability challenge will be a combination of developing the proper technologies combined with the proper standards for handling data. Traceability along the food supply chain is basically the combination of two processes: *intra-enterprise traceability* and *inter-enterprise traceability*. If enterprises working in the same sector adopt different ways to describe the input, the production processes, and the output, it will not be possible to communicate information to providers or consumers.

As a product moves through production and processing stages and beyond, its source and movement along the value chain becomes increasingly challenging to pinpoint. Traceability systems that include premises identification, product identification and movement recording are essential tools to underpin the main drivers for traceability:

- Market access: traceability is a necessity in establishing confidence in the security of the food chain
- Value chain management: knowledge of the precise supply, movement and removal of products over time
- Product differentiation: traceability systems are integral to verify label claims and in supporting consumer confidence, and critical to obtaining and maintaining market share in both the domestic and international marketplace
- Emergency management: premises identification and traceability systems can greatly reduce the resultant consequences through rapid and effective identification of locations and problem sources, isolation of affected animals, plants, foods or persons, protection of non-impacted premises, products or persons and reduction or elimination of the hazard.

Consequently, it is necessary to focus on the adoption of common data references at enterprise level (the farm), to describe e.g. crop protection chemicals, implements, interventions, analysis (soil, milk, etc.) in a consistent way. As traceability at intra-enterprise level is becoming established, traceability at inter-enterprise level may be seen as totally linked to logistics that makes it necessary to have a precise identification of all products.

Traceability data generation, exchange and storage have some costs for the involved parties and each player will expect return on investment, otherwise he will not be motivated to provide the necessary set-up for traceability.

The traceability chain includes a variety of different stakeholders with huge differences in the usage of ICT. Figure 10 illustrates the relations between the different stakeholders based on the flow from farm to fork.

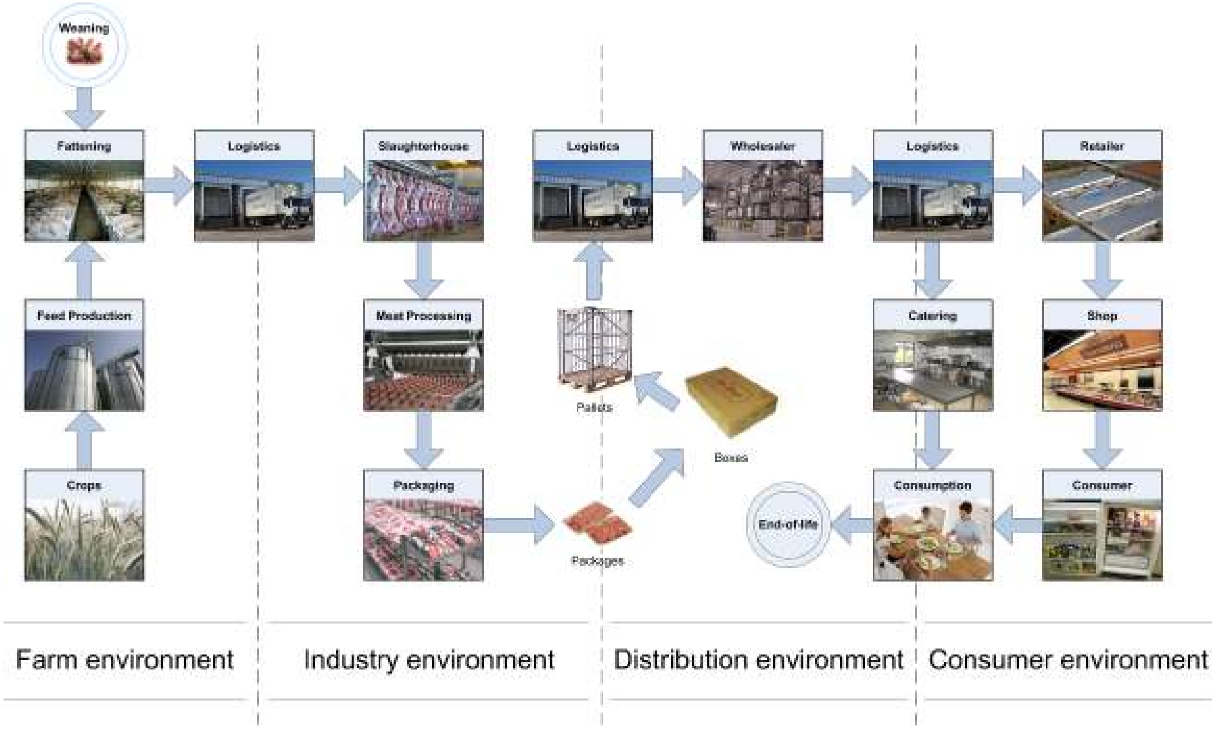


Figure 10 – From farm to fork

Below some of the main interests for each stakeholder will be described, focusing on the benefits in terms of traceability.

7.1.1 Farm environment

The farm environment involves feedstuff manufacturers and farmers of livestock and poultry, with a mutual need for traceability, both for optimisation and in case of food safety issues.

Feedstuff suppliers

A feedstuff supplier's main interest is in ensuring that all ingredients and their composition are documented by origin, genetics, treatment during growth (spraying and fertilising), treatment during storage and transport in order to secure full traceability - especially in case of an emergency, where call-back could be a major undertaking. All kinds of ingredients for different types of animals need to be tracked. In order to optimise future production information relating to e.g. weather conditions, composition (proteins, fat, nutritional information) and the resulting influence on meat quality etc. should be gathered and later combined with information from the farm environment.

Farmers

A farmer's main interest is to be able to correlate the obtained output with the determining factors such as ingredients used, breed of animals, environmental conditions, etc., in order to secure the maximum outcome of his production now and in the future. He needs to be able to track the condition of each individual animal in order to ensure animal welfare, and growth rate as a function of amount and type of food and ingredients. He will also be interested in ensuring documentation/certification of e.g. organic growing of the animal.

Moreover, a farmer will be interested in tracking the individual animal in case of illness in order to provide treatment, put the animal in quarantine etc.

7.1.2 Processing environment

The processing environment covers slaughterhouses and processing companies. These businesses are sometimes combined, and their requirements are often very similar.

In general traceability can be used to improve stock control and to monitor the effect the quality of the farmers' goods have on the quality of the finished goods. Furthermore, both internal and external logistics can be optimised with respect to timeliness, transport distance, storage time, etc.

Slaughterhouses

The interest of the slaughterhouse will be in linking data for the whole animal to each individual cut in order to maintain traceability. Registration and timestamps are required throughout the production process, keeping track of animals, cuts, batch numbers, temperature, humidity, etc., including the meat maturing processes. Likewise, when different products/cuts are combined into a new product this must be registered, as well as yield optimisation data.

Processing and packaging enterprises

In addition to the factors mentioned above, information about additives, flavours and ingredients as well as information about packaging of the final goods must be gathered and documented.

7.1.3 Distribution environment

This area involves wholesale and transportation.

The main interest here for both parties is to demonstrate an unbroken cold chain. A cold chain can be managed by a quality management system, e.g. Hazard Analysis and Critical Control Point, HACCP, where individual tagging can secure that data are measured, analysed, controlled, documented, and validated.

Wholesalers

The wholesalers, and to a lesser degree also the transporters, have a need of managing goods in storage, e.g. after First in - First out principles. Wholesalers moreover need to secure that products have sufficient shelf life left when leaving the warehouse.

Transporters

In addition to that the transporter needs to demonstrate that goods are picked up, and the right amount delivered in the right place at the agreed time.

7.1.4 Consumer environment

This environment covers the retail business and the end consumer.

Retailers

From a retailer's point of view storytelling is of increasing importance. Retail chains are competing with other retail chains, and consumer brands are competing with other brands as well as with private labels from the retail business, all in all to get the most out of branding themselves. Branding is about building trust between a brand owner and a consumer, convincing him that a brand offers special quality and properties. Additional information like recipes and how to make the most out of the purchased food item may be useful to ensure and enforce such a trust. Traceability can provide documentation which will strengthen such a trust relationship.

Consumers

The consumer is the final link in the food chain which started at the farm or even back at the feedstuff supplier. The consumer is also the one who in the end "pays the bill".

The consumers may harbour several concerns relating to the food they have purchased. The most important or primary issues related to food purchases are probably quality and price, not necessarily in that order. For some consumers, other issues will greatly influence their willingness to buy specific food items. Religious, political and personal choices and beliefs are considerations that the retailer needs to address when marketing food. Food safety is becoming more and more important to consumers, who expect the value chain to minimise risks to public health. An important factor is the trust which can be built up between the retailer and the customer regarding the information provided with the food. This trust is increasingly difficult to build because of the industrialisation of the food business and the consolidation of the food market from many small actors to a few large actors.

The consumer basically wants confirmation that everything is fine, and, on top of that, easy access to further information and documentation, maybe in order to check special requirements such as proof that the food is organic, local, sustainable/green, etc. Other properties of interest could be allergens, ingredients, nutrition details such as fat content, energy, vitamins, etc.

8. Scenarios for Food Traceability

In this section we are going to define four scenario storylines which describe different parts of the traceability chain. Each scenario could be considered as an individual case, but they are all interrelated and what connects them is the need for data interchange between the different environments. The investments necessary to provide the necessary set-up for traceability could of course be imposed by legal regulations, but in the scenarios we will focus on highlighting the potential benefits in each environment.

In the scenarios both consumer issues and general food safety issues will be highlighted.

8.1 Scenario scene in Food Traceability

The agricultural domain has now become an integrated IT platform where data floats between the different sub-domains. All cows and pigs are uniquely identified; all ingredients in feedstuff have become traceable as well as every piece of meat in the stores. Animal identification is based on RFID tags.

Data recorded in the production chain are stored as a combination of local storage on farm computers, ERP systems at the production plants (feedstuff, slaughterhouses and retail) and centralised servers at national level. The centralised servers mainly contain general information that makes it possible identify and to locate all feedstuff, animals and food products, whereas more detailed historic information related to the agricultural products is stored locally.

Recently imposed regulations on confinement and stocking densities have been instrumental in improving animal welfare.

8.2 Food Traceability scenario

The implementation of novel ICT systems in the agricultural domain has very significantly improved food traceability in the EU. All information is exchanged via dedicated web services, which collect the relevant data from national servers, business ERP systems and local farm computers. These exchanges are made without compromising the integrity and security of sensitive business data.

Because of the exchange of information feedstuff manufacturers and farmers can react very quickly on emerging trends in animal responses to variations in their feed. Likewise data can be exchanged between slaughterhouses and farmers to correlate individual animal development with projected consumer demands and promotion campaigns.

Livestock farming is ubiquitously monitored, and great advances have been made in predicting and preventing illnesses, thus reducing the need for medication. The ICT system is self-regulating; the widespread use of interconnected wireless sensors allows automatic adjustments in response to changes in internal and external conditions.

If so desired, the consumer has access to detailed information relating to the history and quality of purchased products, e.g. origin, animal breed, feedstuff characteristics, medical treatment, etc. This is particularly relevant for ecological and other special-brand foods.

Headline hitting food safety scares like Mad Cow Disease, dioxin-contaminated feed and adulterated olive oil are a thing of the past. The comprehensive food safety strategy within the EU keeps risks to a minimum with the help of modern food and hygiene standards drawn up to reflect the most advanced scientific knowledge. Food safety starts on the farm, and the rules apply from farm to fork, whether the food is manufactured in the EU or is imported from elsewhere in the world. And response times in case of potential risks have been substantially reduced.

8.2.1 Feedstuff manufacturing storyline

Bob is head of logistics at GoodFeed, the largest feed producing company in Northern Europe. They have few competitors; the consolidation in the business during the latter years has left only a limited number of large suppliers of feedstuff for pigs, cattle and poultry.

Ingredients for the feed production come from all over the world by ship, train or truck. Due to the increasing demands from farmers, consumers and governments for traceability, it is Bob's responsibility to ensure that all ingredients, whether it is crops from a field in the neighbourhood or soy beans from South America, are documented by origin, genetics, treatment during growth (spraying and fertilising), and conditions during storage and transport. All this information is stored on GoodFeed's servers and made available to the customers and the government.

Each customer (farmer) has storage facilities with capacity equal to 1-3 weeks of feed consumption. The pig producing customer typically uses 4-6 different types of feed for different types of animals such as pregnant sows, farrowing sows, weaners, young finishers and older finishers. The feedstuff is stored in silos at the farms and all these silos are equipped with sensors that measure current stock.

The ICT based management system on each farm calculates expected consumption of the different types of feed, based on current production. All information is automatically delivered to GoodFeed's server every night, and based on these data the ERP system calculates the production and delivery plan for the next day. The customers want just-in-time delivery to minimise tied-up capital and decrease production costs.

The feedstuff is transported by truck from the feed mill to the farm, and for each delivery all information about batch number, silo ID, amount and time stamp is automatically transferred to the management system on the farm. Through a web service based interface to GoodFeed's servers every customer (farm) can look up all relevant information about delivered feed, using the batch number as key.

Government regulations have required GoodFeed to establish a trace-back/trace-forward system for all ingredients used in the feed. If any health threatening problem should be discovered in an ingredient, GoodFeed immediately must be able to supply information about the farms and silos that have received feedstuff with the given ingredient. The management systems on the farms will then be able to tell which animals were fed with the offending feed, and by combining this information with ERP data from the slaughterhouse and retail, potentially affected meat can be removed from the stores.

In the past GoodFeed spent a lot of money on trials at test farms to improve and verify their different types of feedstuff. Now, with the fully established traceability system based on GS1 and EPC standards, all production data are gathered and used as one big trial. The slaughterhouse reports back information to the farmer about weight, meat percentage and other observations based on RFID identification of the individual slaughter pigs. At the farm information about growth rate and meat percentage is combined with the records from the feeding system, showing exactly which batches of feed were given to which particular animal. In this way the total pig production produces data as if it were one huge trial.

8.2.2 Pig farming storyline

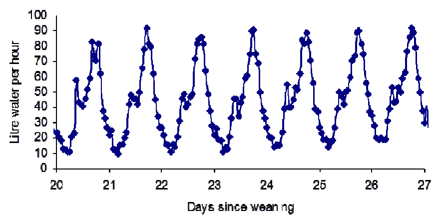
John is running a pig producing company, as he chooses to call it. His father was a farmer producing crops, milk and pigs on their family farm. John's father employed two persons and had a production of milk from 75 cows, produced 4,000 slaughter pigs from his 200 sows and produced his own feed for the animals with crops from his 60 hectares of land.

John's father stopped his agricultural production in 2009 as many other farmers with the same size of production have done. They have sold their land to farming companies, typically owned by a farmer in combination with financial shareholders. John's company consists of a production facility for housing 6,000 sows, each producing 33 weaners per year, and a facility for growing the 200,000 fatteners from their weaning weight of 7 kg to their optimal slaughter weight of around 100 kg.

From the outside the production facility looks like any other factory, and John's company only owns the land the plant is built on. All waste products from the pig production, such as slurry, are sold to crop producing companies, who use it as fertiliser in the fields. Due to legal regulations, the production plant is equipped with expensive air cleaning systems, preventing gasses like ammonium and offensives odours from polluting the environment.

On average, the production on John's company requires around 175 tons of feed every day. The feedstuff is delivered by trucks from the feedstuff manufacturer GoodFeed and each delivery comes with detailed information about the content in the specific batch of feed. All information about the contents is available through web services on GoodFeed's server, and John's management system is updated every night with detailed information about the delivered feed.

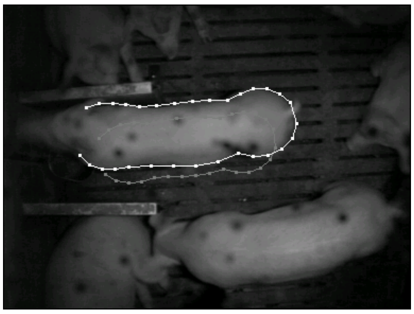
John employs fourteen people, many of them coming from Eastern Europe. Ten persons are occupied with the sows while four are working with the slaughter pig production. This means that the average manpower spent on producing one slaughter pig from weaning to slaughter (over a three-month period) is approx. 2 minutes. This efficiency is only obtainable because John's company makes heavy use of the available ICT technologies.



First of all, they are using the new high frequency RFID tags on all animals – each pig gets its unique tag right after birth, and for traceability all data relating to genetics (mother and father) are immediately stored on the company's local server as well as on the national server. The new high-frequency RFID tags can be read by antennas at a distance up to 4 meters, and such antennas are placed in many locations in the production plant. This means that all transfer of pigs from one section to another is recorded automatically, and each time a pig chooses to eat or drink, the amount consumed is stored with a time stamp. These data are very important for the automatic surveillance systems that are used for monitoring the well-being of the animals. Dynamic statistical models are used to interpret the data collected from monitoring the drinking and eating behaviour of each animal, and alarms are issued in case of deviating behaviour.

Deviating animals are automatically led into an observation pen where the staff can examine and treat them. All treatments of the pigs are reported by use of a mobile device. It reads the RFID tag on the pig and the caretaker enters the type of treatment and medication. These data are stored locally on the company's server.

All slaughter pigs are monitored by IP cameras and data are used for detecting deviating behaviour as well as for estimating daily gain and weight of the individual animals, by use of image analysis. In that way, the management system is able to predict delivery to the slaughterhouse and



automatically decide when to ship the animals for slaughter, depending on the actual needs and capacity on the slaughterhouse.

In addition to the bulk production of fast-growing slaughter pigs, John's company also has a smaller production of special high-quality meat. The genetics used for this special production differs from the bulk production, i.e. the focus is on the taste of the meat and not on maximal growth rate. These animals also receive a different and more expensive feed based on ecologically grown components. The production cost of these pigs is 50 percent higher than the bulk production, but this is compensated by the price paid by the slaughterhouse. To get the higher price it is a requirement that all production data for each animal are available electronically at the slaughterhouse and ultimately at the consumer end.

When a slaughter pig enters the truck for transportation to the slaughterhouse, it is automatically recorded by antennas on the delivery ramp as well as on the truck. A final tracking record for each animal is generated on the farm management application server and made public. This record contains information about genetics, feedstuff consumed, growth rate, any anomalies observed during the growth period and any medical treatment given.

8.2.3 Slaughterhouse storyline

At the slaughterhouse PrimeMeat they slaughter around 30 million finishers every year. One of the big challenges in large-scale slaughtering is optimisation of the processes in terms of getting the right number of pigs of the right size in relation to the slaughtering capacity and the demand from retail. Traditionally, the farmer just delivered his pigs for slaughter when they had the right size which caused some logistic challenges for the slaughterhouse.

But now the senior manager in Production Planning has introduced a new ICT based management and planning system for optimisation of the production, based on information from the Traceability Tracking system FoodPrint.

The planning system collects production data from all suppliers every night, including information about weight and growth rate for the individual finishers. This course of action has been possible since the standard RFID tags and vision based weight estimation were introduced on the farms a few years ago. Based on these data the slaughterhouse forms a status map of all available animals and makes supply forecasts by including historical data.

Another part of the system is in contact with the retailers' ICT systems and gathers information about consumer behaviour. Since the shops introduced "dynamic" prices on meat (depending on the age and quality) the slaughterhouses have discovered that analysing the consumer's behaviour can provide valuable information and help optimising the profit.

By combining information on consumer behaviour with the current status of available pigs the slaughterhouse can now request pigs from the farms in a way that optimises earnings for both the farmer and the slaughterhouse.

During the slaughtering process a sequence of measurements is performed on each carcase, for instance meat percentage in different parts of the animal and the size and shape of the different cuts. This information is stored in FoodPrint and automatically fed back to the supplier (the farm server) who uses it for optimisation of his production in relation to breeding and choice of feed components.

Another major advantage of FoodPrint is that the slaughterhouse can slaughter special-brand pigs in-between the traditional bulk pigs, because they now have unique ID and traceability for every animal. Before introducing this system, they had to empty a slaughter line before they were able to handle animals of another quality.

8.2.4 Consumer storyline

Mrs. Hanson is a quality-aware consumer now standing at the refrigerated counter in the local supermarket looking for a package with four cutlets. She discovers that there are three different variants of the product and that they are priced very differently. She asks an employee in the store about the differences in the three packages of cutlet and he answers "I don't know what the difference is, but try to beep them for their history". Mrs. Hanson takes out her iPhone 7 (which comes with an RFID reader), holds it over the first package of meat and pushes the button 'Beep RFID'. The screen now displays a list of the entire value chain that the product has gone through in its lifecycle, including transportation and retail. The list includes a timestamp for each step in the chain and a green marker is shown on each line if all requirements about storage temperature and storage time in the given step of the process are kept within the limits.

Mrs. Hanson now beeps the second package, which is 40 percent more expensive than the other two, and from the screen on the iPhone it appears that this product has the label "Special Quality". By clicking the Farm icon it now appears that the meat is from a pig grown at a farm called 'John's Pig Enterprise' and that it is from their special production. She further learns that the meat has genes which imply slower growth of the pig but better taste of the meat. From the production log it appears that the animal of this special production has had 30 percent more space than traditional bulk produced pigs, has been fed ecological feedstuff (no GMOs) and has been given no antibiotics.

All together Mrs. Hanson has now spent one and a half minute investigating the meat packages and she chooses the expensive one.

Mrs. Hanson is very excited about this new possibility and asks the employee in the store how they use all this information themselves. He explains that the store just has installed a brand new optimisation system on their ICT platform. It automatically collects historical information for all meat packages delivered to the store. The system immediately loads all log data regarding timestamps for the steps since slaughter and detailed information about storage conditions during the production chain since slaughter. Based on this information the optimisation system calculates a quality parameter and an expiry date. The quality parameter is used to set the price of the product. The system also ensures the store proper price reductions on meat with a calculated quality parameter below the agreed level.

A few days later the Hanson family visits the best steakhouse in town to celebrate a birthday. The restaurant is very keen about the quality of their meat, which also is reflected in the price level. When the family has got their table, they discover that the traditional menu card of paper has been changed with an iPad-looking device. On the device there is an overview of the different types of menus in the restaurant, but there are no prices! When clicking one of the menus on the screen, a new screen appears with an overview of the meat currently available in the kitchen for this dish. Each variant of the menu has its individual price (varying more than 100 percent) depending on the chosen meat. Mrs. Hanson chooses a piece of fillet from a Chevrolet calf which has been grown with ecological feed and has never been treated with antibiotics. The fillet has hung 90 days after slaughter in the Meat Processers special facility for maturing meat. It is a very expensive choice but Mrs. Hanson is willing to pay the price for good quality. Her husband on the other hand is more concerned about his money and he wants the cheapest version of the menu and does not care about the breed of the calf, ecological feed or ethical issues. He just checks that the calf has not received any antibiotics and then he orders.

When the Hansons return home after their dinner, they discover that the headline story in the news is about a potential food scandal. It turns out that a feed mill by accident has made a batch of feedstuff containing a considerable amount of dioxin. Potentially the dioxin could end up in meat all over Europe. But after a few minutes, the minister of food turns up on the screen and calms everybody down: "…yes it is a scandal, but we have the situation under full control" he said. Because of the unique identification system which facilitates full traceability all animals that have eaten the contaminated feedstuff could easily be identified and a complete list of IDs on packages of meat affected could be generated. Thanks to the ICT systems in the supply chain all packages of meat affected could be identified and removed from storage and stores. Luckily the affected meat had not yet reached the counter in any stores.

8.3 Scenario use case diagrams

The purpose of use cases and use case diagrams is described in Section 6.4.

In Appendix 2 are shown 12 high-level use case diagrams.

Four diagrams are derived from the Feedstuff manufacturing storyline in Section 8.2.1, five from the Pig farming storyline in Section 8.2.2, one from the Slaughterhouse storyline in Section 8.2.3 and two from the Consumer storyline in Section 8.2.4.

These use cases will be further developed and used for elicitation of user requirements in the requirements engineering process; they can also work as basis for the work undertaken in WP3 pertaining to the description of enterprise and management processes in the domain.

9. Scenario Interpretation – Planning the Requirements

In this section we summarise the future developments foreseen by the experts and the significance this will have for the development of the two ebbits applications in 2015 and beyond. The future scenarios describe end user activities as well as application functionalities, and we will try to bridge the gap to the formulation of technical user requirements, which will be reported in D2.4 Initial requirements report and which will contribute to the definition of the open, service-oriented architecture evolving from WP5, WP7 and WP8. In other words, we will try to dress the scenarios with additional comments on aspects of functionality and implementation as seen from a developer user's point of view.

The objective is not to derive requirements but to facilitate the understanding of which thoughts and ideas went into the future scenarios during the Scenario workshops and subsequent preparation of the storyboards.

9.1 Automotive Manufacturing

The future evolution of the automotive plant will be influenced by the same parameters that have been considered most important for the development of the companies in recent years: reduction of cost, improved quality and higher productivity. In addition, since all European Community member states have signed and ratified the Kyoto protocol, the car manufacturers will have to drastically reduce their carbon footprint.

To achieve these goals companies involved in the development of the plant of the future will strive to provide integrated solutions introducing encapsulated mechatronic components, comprising a mechanical part and an electronic part which jointly can perform a simple job. Using these mechatronic components, complex machines can be constructed that are able to monitor and control themselves and react to the change in parameters inside or outside the perimeter of the mechatronic object, acting in conjunction with other objects surrounding them in the manufacturing plant.

Such mechatronic objects will sustain the modularity necessary in the plant to increase the flexibility of the production, and in particular to react to the variations in market demand.

The architecture based on distributed mechanical units, equipped with controllers, will need an innovative monitoring and coordinating system. This system will have to provide features to change the composition of the production process, to control the behaviour of the production, to manage all activities ensuring optimum efficiency and to monitor completely the performance, reporting information to evaluate the indicators of cost, quality, productivity and energy consumption of the manufacturing plant.

9.2 Food Traceability

Both governments and the general public consider agricultural production a matter of concern for the environment and the use of natural resources. Food safety, food history and animal welfare are quite unique to this domain, and these issues are often subject to unfavourable press attention.

Though many European farmers are still located in rural areas and use very traditional farming methods, ICT technologies for agriculture are rapidly becoming more and more important and more and more innovative.

Farming methods will be influenced by the use of innovative ICT technologies, which will enable producers to make high-quality products that meet the high demands of the market. In addition to facilitating traceability, some producers will see clear advantages in using ICT to optimise their processes and the quality of their products.

A major problem is to have ICT systems reflect the complexity of the domain, i.e. the various subsystems must be able to communicate with each other to a much larger extent than today to achieve full farm-to-fork traceability. On the other hand, farmers are inclined to ask for proof of real cost/benefit, before they invest in new ICT solutions.

For the "political consumers", who are often well-informed and well-educated, individual attitudes and values are central, and their political demands are projected more and more directly onto the market and the business community. They are usually willing to pay premium price for premium products, and they may favour organic, non-GMO-based products and even in some cases prefer the products coming from traditional farms over the results of hi-tech production in various food industries.

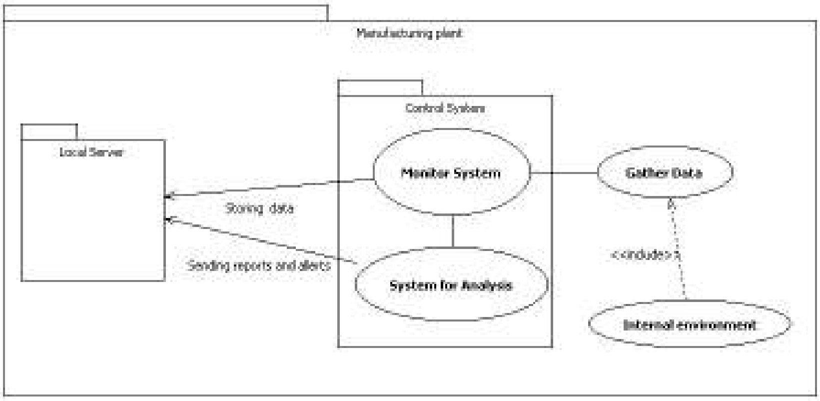
Other consumers are indifferent to almost anything but prices, and for this segment ICT solutions will have to be focused on innovations in production methods which can lower the cost of production.

10. Appendix 1

Use Case Diagrams in Automotive Manufacturing

Use case 6.2.1.1 – Monitoring and storing of data

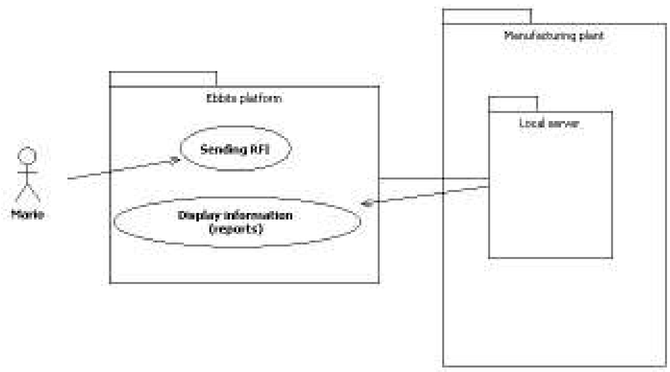
Use Case Name	6.2.1.1 – Monitoring and storing data
Version	1.0
Author	COMAU, TUK
Last update	29/11/2010
Assumptions	
Pre-conditions	Monitoring system is implemented in the company
Successful End Condition	Gathered and stored data, Reports from the System for analysis
Actors	Monitor system, Control system, System for analysis, Local server
Use Case Initiation	Monitoring is provided continuously
Main flow	1. Monitor system collects data (from the sensors in the internal environment) 2. Monitor system stores data on the local server 3. Monitor system sends data to the System for analysis 4. System for analysis provides analysis 5. System for analysis sends reports to the local server
Post-Conditions	



Note:

Use case 6.2.1.2 – Checking the status of the manufacturing plant

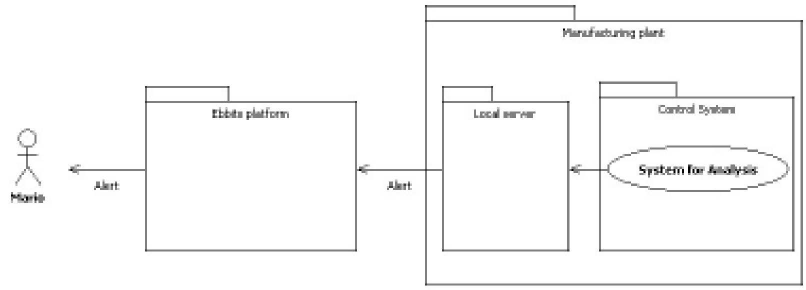
Use Case Name	6.2.1.2 – Checking the status of the manufacturing plant
Version	1.0
Author	COMAU, TUK
Last update	29/11/2010
Assumptions	
Pre-conditions	Mario has access to the ebbits platform, the ebbits platform is connected with the local server of the manufacturing plant
Successful End Condition	Mario receives report about the status of the plant
Actors	Local server, Mario, ebbits platform
Use Case Initiation	Use case starts on Mario's demand
Main flow	1. Mario connects to the ebbits platform and sends Request for Information (RFI) 2. Ebbits platform connects to the local server 3. Real time reports about status of the plant are displayed
Post-Conditions	



Note:

Use case 6.2.1.3 – Sending alert to Mario

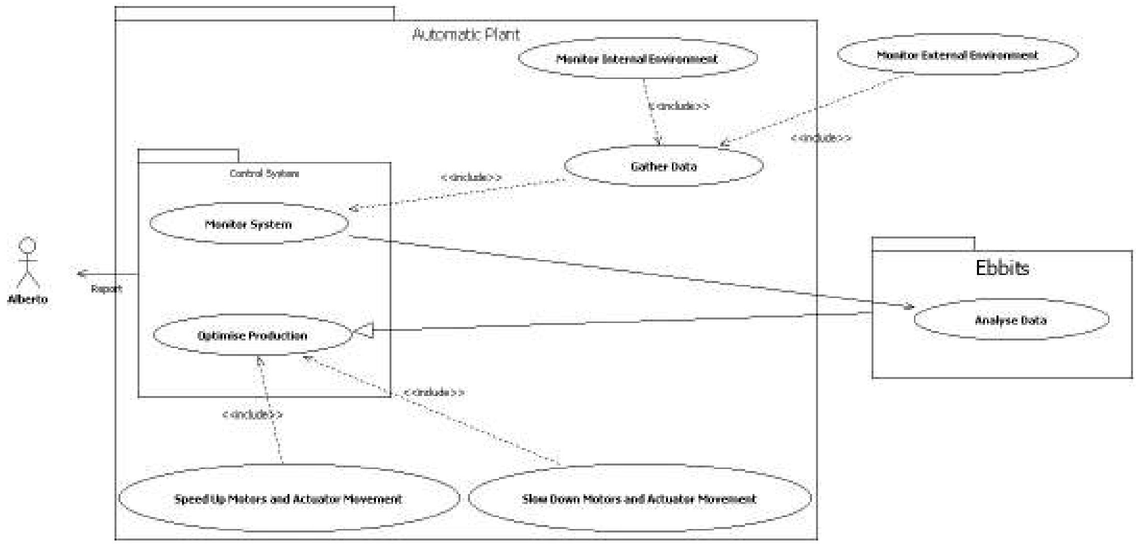
Use Case Name	6.2.1.3 Sending alert to Mario
Version	1.0
Author	COMAU, TUK
Last update	29/11/2010
Assumptions	
Pre-conditions	Mario has access to the ebbits platform, the ebbits platform is connected with the local server of the manufacturing plant
Successful End Condition	Mario receives alert about the changed status of the plant
Actors	Local server, Mario, ebbits platform
Use Case Initiation	Use case starts when the system for analysis finds anomaly in production process
Main flow	1. System for analysis sends a report about an anomaly in the production process to the local server 2. Local server sends alert to the ebbits platform 3. Ebbits platform sends alert to Mario
Post-Conditions	



Note:

Use case 6.3.1.1 Production optimisation

Use Case Name	6.3.1.1 Production optimisation
Version	1.0
Author	COMAU, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	Monitoring system connected with the ebbits platform
Successful End Condition	Report about optimised production and energy usage
Actors	Alberto, ebbits, Control system
Use Case Initiation	Monitoring and optimisation is provided continuously
Main flow	1. Monitor system collects data (including internal environment and external environment) 2. Monitor system sends collected data to the ebbits platform 3. ebbits platform analyses data 4. ebbits platform sends a request for optimised production to the control system 5. Control system generates a report about the optimised production
Post-Conditions	



Notes: 1) Please check the role of ebbits 2) Activities hidden behind 'internal' and 'external' would be useful to break down to lower levels and to make explicit actors involved, including dependencies between them.

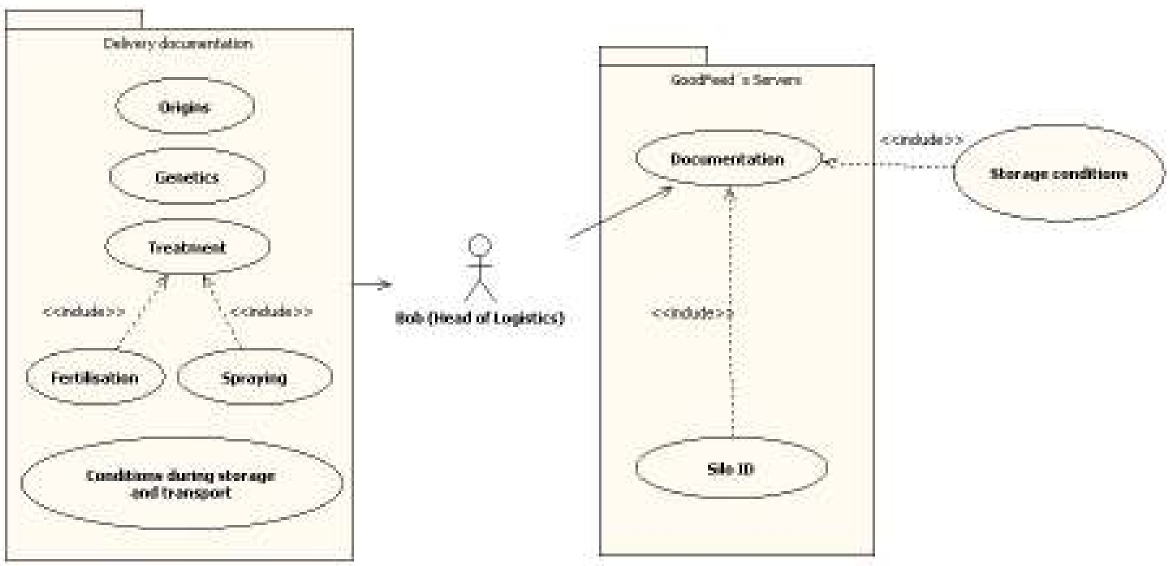
11. Appendix 2

Use Case Diagrams in Food Traceability

In the use cases below, though in most instances the role of ebbits is not stated, it is implicitly understood that the ebbits role is that of facilitating retrieval and sometimes also processing of data, which are stored in discrete data storages and linked via the traceability chain.

Use case 8.2.1.1 - Information about delivered feed

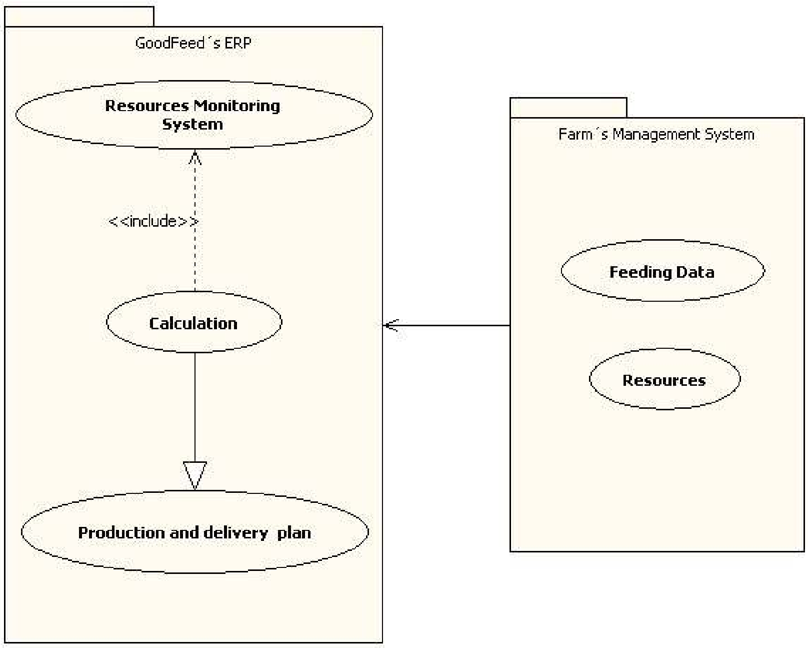
Use Case Name	8.2.1.1 - Information about delivered feed
Version	1.0
Author	TNM, TUK
Last update	15/11/2010
Assumptions	
Pre-conditions	Bob has access to GoodFeed´s servers
Successful End Condition	Updated information on GoodFeed´s servers
Actors	GoodFeed´s servers, Bob
Use Case Initiation	Use Case starts when delivery arrives
Main flow	1. Bob logs into GoodFeed´s server 2. Bob enters details about delivery (origin, genetics, treatment, conditions during storage and transport) 3. Bob assigns ID of silo to delivery 4. Bob saves and publishes all information 5. Bob logs out from GoodFeed´s server
Post-Conditions	System monitors storage conditions and updates information



Note: Data regarding delivery documentation are uploaded either manually or it is possible to use RFID (or other device) to provide this process automatically.

Use case 8.2.1.2 – Calculation production and delivery plan

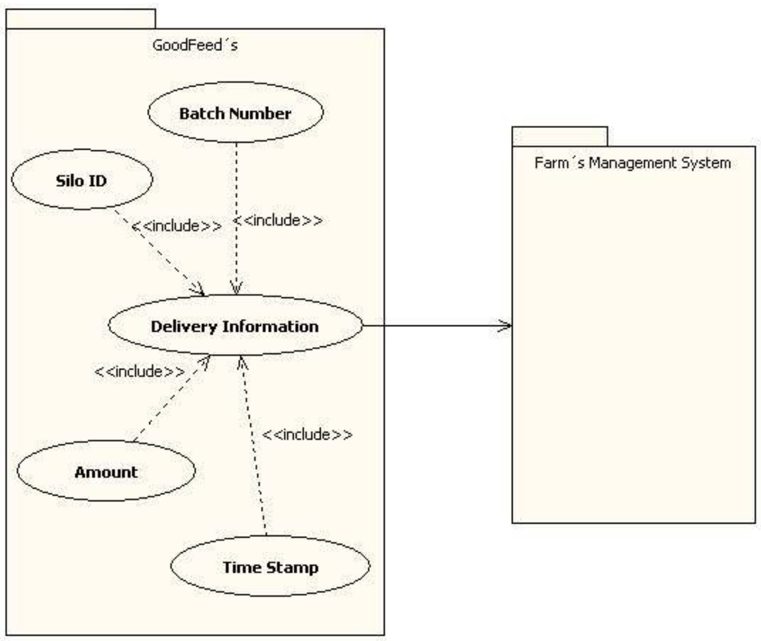
Use Case Name	8.2.1.2. – Calculation production and delivery plan
Version	1.0
Author	TNM, TUK
Last update	15/11/2010
Assumptions	
Pre-conditions	ICT management system (MS) on the farm Farm's MS (FMS) is connected with GoodFeed's ERP system
Successful End Condition	GoodFeed's ERP system calculates production and delivery plan
Actors	FMS, GoodFeed's ERP
Use Case Initialization	Every night
Main flow	1. FMS collects data about feeding 2. FMS every night automatically sends data to GoodFeed's ERP via secure connection 3. GoodFeed's ERP updates data and provides calculation and generates production and delivery plan
Post-Conditions	



Note:

Use case 8.2.1.3 – Feedstuff delivery

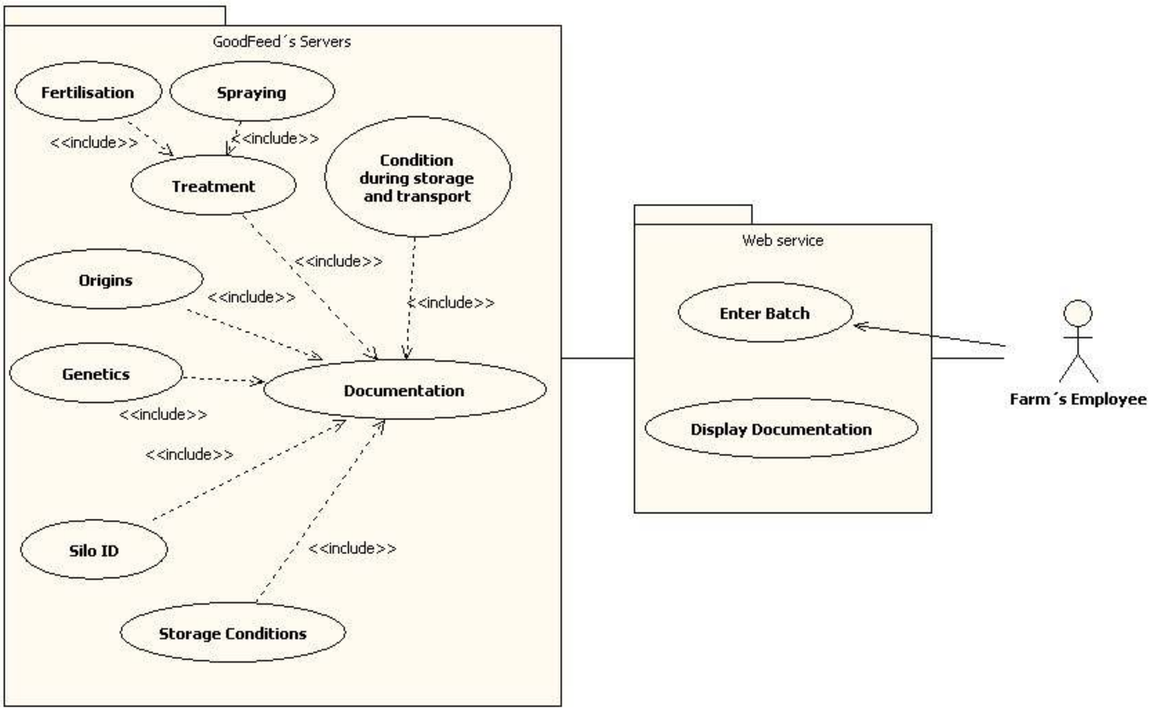
Use Case Name	8.2.1.3 – Feedstuff delivery
Version	1.0
Author	TNM, TUK
Last update	15/11/2010
Assumptions	
Pre-conditions	Delivery plan generated in use case 8.2.1.2 ICT management system (MS) on the farm
Successful End Condition	Updated data in FMS
Actors	GoodFeed´s ERP, FMS
Use Case Initialization	Use case starts delivery is calculated and executed
Main flow	1. GoodFeed produces feedstuff 2. GoodFeed sends truck with feedstuff to farm 3. GoodFeed automatically transfers information about delivery (Batch number, Silo ID, Amount, Time stamp) to FMS
Post-Conditions	



Note:

Use case 8.2.1.4 – Invoke information about delivered food

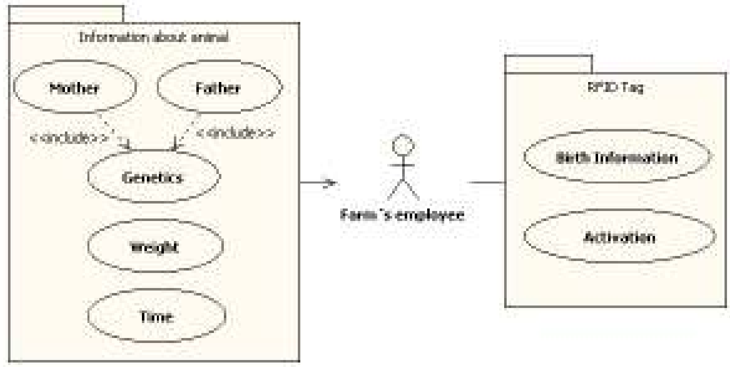
Use Case Name	8.2.1.4 – Invoke information about delivered feed
Version	1.0
Author	TNM, TUK
Last update	15/11/2010
Assumptions	
Pre-conditions	Batch number (key)
Successful End Condition	Successful log into GoodFeed´s servers and receive information
Actors	GoodFeed´s servers, Web service, Farm employee
Use Case Initialization	Use case starts on the Farm employee demand
Main flow	1. Farm employee accesses web service 2. Farm employee uses Batch number as key 3. Web service connects to GoodFeed´s servers and accesses information about the delivered feed 4. Farm employee leaves web service
Post-Conditions	System creates and saves log information



Note:

Use case 8.2.2.1 – Implementation and activation of RFID tag

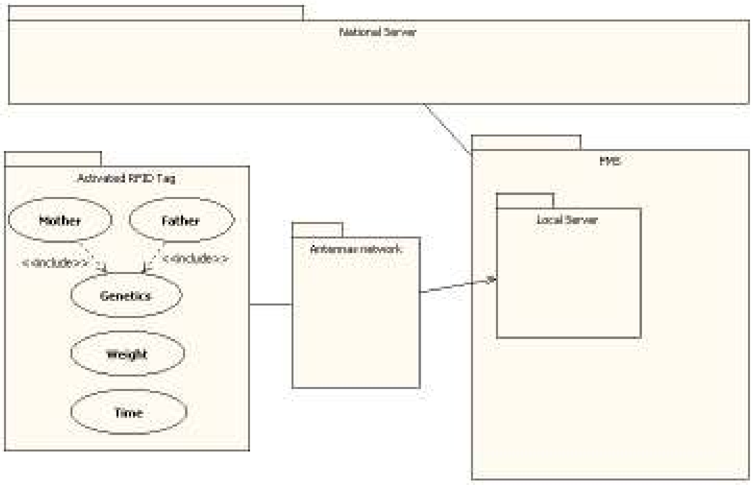
Use Case Name	8.2.2.1 – Implementation and activation of RFID tag
Version	1.0
Author	TNM, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	Equipment for RFID tag implementation
Successful End Condition	Implemented and activated RFID tag
Actors	Farm employee
Use Case Initiation	Immediately after animal birth
Main flow	1. Farm employee implants RFID tag to the animal 2. Farm employee uploads detailed information about weight, genetics and time of birth to RFID 3. Farm employee activates RFID tag (each animal has unique ID)
Post-Conditions	RFID Tag transmits information



Note:	

Use case 8.2.2.2 – Storage information about animals

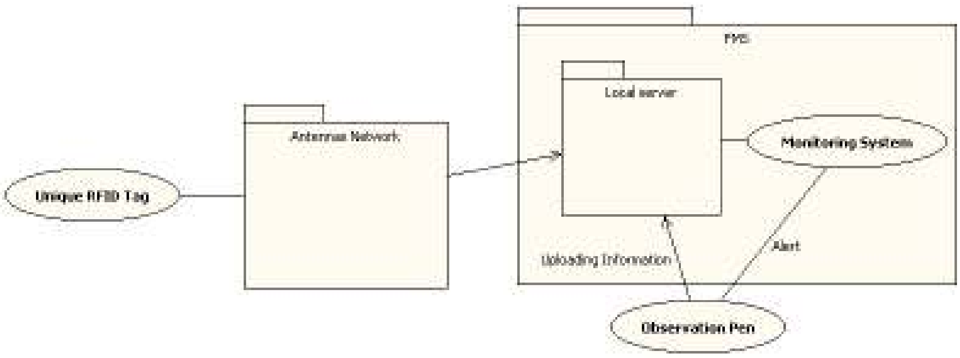
Use Case Name	8.2.2.2 – Storage information about animals
Version	1.0
Author	TNM, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	Activated RFID Tag, Antennas (for reading RFID) network FMS is connected with National server
Successful End Condition	Updated information on the farm local servers and National server
Actors	National server, FMS
Use Case Initiation	Use case starts after successful completion of the use case 8.2.2.1
Main flow	1. Antennas read unique ID of the animal 2. Information is uploaded and stored in the local server 3. FMS sends information to the National server
Post-Conditions	



Note:

Use case 8.2.2.3 – Monitoring of feeding and identification of deviations in behaviour of animals

Use Case Name	8.2.2.3 Monitoring of feeding and identification of deviations in behaviour of animals
Version	1.0
Author	TNM, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	Activated RFID Tag, Antennas (for reading RFID) network Observation pens
Successful End Condition	Updated information on the local server
Actors	FMS, Employee's observation pens
Use Case Initiation	Monitoring is provided continuously
Main flow	1. Antennas network monitors movement of animals and feeding (amount of consumed feed and water is sent to the local server with a time stamp) 2. Information is uploaded to the server 3. Monitoring system monitors feeding and alerts about deviated behaviour (according to the amount of discrepancies of feed and water) 4. System sends an alert to employee's observation pen 5. Caretaker enters the type of treatment and medication 6. Information is uploaded to the server
Post-Conditions	



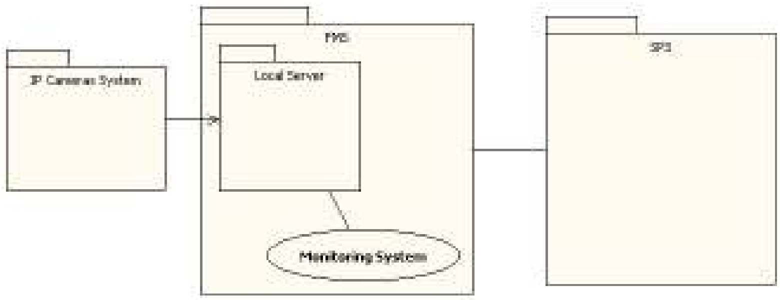
Note:

Use case 8.2.2.4 – Special production

Use Case Name	8.2.2.4 Special production
Version	1.0
Author	TNM, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	All from 8.2.2.1, 8.2.2.2, 8.2.2.3
Successful End Condition	Updated information about special production
Actors	All from 8.2.2.1, 8.2.2.2, 8.2.2.3
Use Case Initiation	All actions are provided as in the use cases 8.2.2.1, 8.2.2.2, 8.2.2.3
Main flow	1. Use case 8.2.2.1 for special production 2. Use case 8.2.2.2 for special production 3. Use case 8.2.2.3 for special production
Post-Conditions	

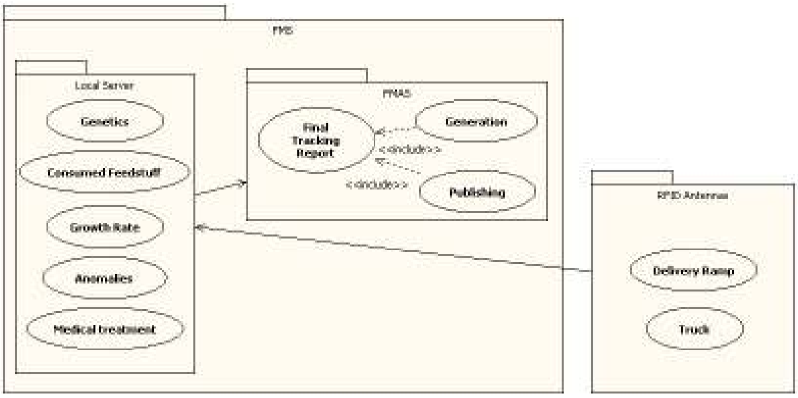
Note:

Use case 8.2.2.5 – Prediction of delivery to slaughterhouse

Use Case Name	8.2.2.5 Prediction of delivery to slaughterhouse
Version	1.0
Author	TNM, TUK
Last update	18/11/2010
Assumptions	
Pre-conditions	IP Cameras network
Successful End Condition	Report from FMS
Actors	FMS, Slaughterhouse Planning System (SPS)
Use Case Initiation	Prediction is provided continuously
Main flow	1. IP camera system monitors animals 2. Data are uploaded to the local server 3. System monitors growth and predicts date of optimal slaughter weight 4. FMS every night sends data to SPS
Post-Conditions	
	
Note:	

Use case 8.2.3.1 – Animal transportation to slaughterhouse

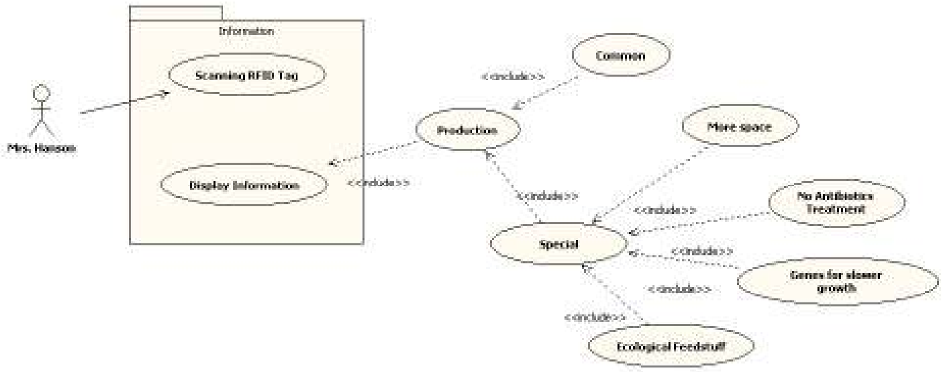
Use Case Name	8.2.3.1 Animal transportation to slaughterhouse
Version	1.0
Author	TNM, TUK
Last update	17/11/2010
Assumptions	
Pre-conditions	RFID Tag, Antennas for reading RFID
Successful End Condition	Final Tracking Report
Actors	FMS, Farm’s Management Application Server (FMAS)
Use Case Initiation	Use case starts when animals enter the truck for transportation
Main flow	1. Antennas (on delivery ramp and on the truck) read RFID Tags 2. Antennas send information to FMS 3. FMS collects all information about all animals from the local server (information about genetics, consumed feedstuff, growth rate, anomalies during growth, given medical treatment) 4. FMAS generates and publishes Final tracking report
Post-Conditions	



Note:

Use case 8.2.4.1 – Receiving information about the meat

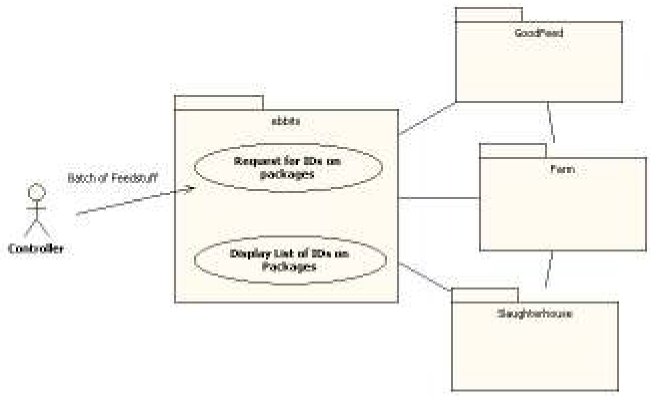
Use Case Name	8.2.4.1 Receiving information about the meat
Version	1.0
Author	TNM, TUK
Last update	17/11/2010
Assumptions	
Pre-conditions	Mrs. Hanson has a device for RFID scanning
Successful End Condition	Received information
Actors	Mrs. Hanson (consumer)
Use Case Initiation	Use case starts at Mrs. Hanson demand
Main flow	1. Mrs. Hanson scans RFID 2. Mrs. Hanson receives information
Post-Conditions	



Note:

Use case 8.2.4.2 – Identification of potentially infected meat packages

Use Case Name	8.2.4.2 Identification of potentially infected meat packages
Version	1.0
Author	TNM, TUK
Last update	17/11/2010
Assumptions	
Pre-conditions	Food tracking system
Successful End Condition	List of IDs on packages
Actors	Controller, ebbits Platform
Use Case Initiation	Use case starts at Controller demand
Main flow	1. Controller sends a request for a list of IDs of meat packages (potentially infected – according to batch of feedstuff) 2. SPS generates a list of IDs of meat packages
Post-Conditions	



Note:

1 IoPTS http://www.companionable.net
2 COMAU http://www.comau.com
3 TNM A/S http://www.tnmit.dk
4 TRACE http://www.trace.eu.org