



ARCHITECTURAL MODEL REPORT

FOR FIELDFACT DEMONSTRATOR APPLICATIONS

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FIELDFACT-WP3-ALT-DEL-3.4



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Architectural Model Report

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FOREWORD

This report is prepared in the framework of the FieldFact project.

The FieldFact project was initiated by GJU for the introduction and promotion of GNSS in the agricultural community. It is co-financed by the GALILEO Joint Undertaking (GJU) under the 6th Framework Programme. There are six consortium partners participating in the project - Alterra, Vexcel (as per 1st of February replaced by Terrasphere) and PPO from the Netherlands, University of Warmia and Mazury (UWM) from Poland, Ekotoxa Opava from the Czech Republic and the European Commission's Joint Research Centre. Starting the 1st of February 2007, the business activities of Vexcel were terminated and the remaining work in the project have been transferred to Terrasphere,

In the agricultural sector, GNSS applications have not yet been widely used, even though interest in them has been on the rise. They require investments in equipment, but also in specialized inputs, services and skills. The pace of adoption of precision agriculture has slowed in recent years compared to the mid- and late 90's. The spread of GNSS use has been hindered also by occasional inadequate accuracy, availability, reliability and continuity of the Signal in Space (SIS) of current GNSS and a lack of beneficiary applications. The opinion of the user community on the possible benefits of GNSS is changing however, influenced by a number of external and internal factors. Production chain parties and governments demand more extensive and accurate documentation including spatial data on the agricultural production process, the production site, and agricultural products. On the technical side, equipment is getting cheaper, more energy efficient, more advanced, and readily available to the user community.

GALILEO is expected to accelerate the use of GNSS by the agricultural community by reducing the currently existing barriers in the field of accuracy, availability, reliability and continuity of the SIS. In combination with the mentioned developments and change of opinion in the user community, this leads to new opportunities and new feasible applications in agriculture.



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EXECUTIVE SUMMARY

The Architectural Model Report for FieldFact demonstrator applications describes part of the work performed in the task functional and non-functional analysis as defined in work package 3 (Applications) of the FieldFact project. In the FieldFact project, the architectural model will serve as a basis for the technical implementation of the demonstrator applications. It should therefore comply with the set of requirements defined for the FieldFact demonstrator applications in previous tasks of the project.

The basis of the presented architectural model is the general architecture of the GALILEO system. With a stepwise refinement method, using the global architecture of the GALILEO infrastructure as a starting point, the "Application Segment" defined within this architecture has been elaborated to an architectural design of the FieldFact Application Segment. The architectural model has been derived from a commonly used web-based 3-tier architecture, but has been slightly adapted to match with specific needs that apply to applications in the agricultural sector.

To verify the defined architectural model, a compliance analysis was performed, matching the developed architectural model with the requirements for the FieldFact demonstrator applications that have been defined in earlier tasks in the FieldFact project. The resulting conclusion is that virtually all relevant requirements are supported by the characteristics of the architectural model.

Moreover, the presented architecture will not only fit the needs of the FieldFact project, but can also serve as a guideline or reference model for other GNSS and especially GALILEO supported applications in the agricultural community.



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1 INTRODUCTION

1.1 Purpose and scope

This document describes the architectural design for the demonstrators to be developed in the framework of the FieldFact project. As there is no strict definition of which aspects constitute a system architecture, and as various organizations define it in different ways, the term architectural design for the purpose of this document will be defined according to IEEE 1471 as: “The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution” [2].

With that regard the purpose of this document is to describe the allocated arrangement of physical components which provides the design solution for the FieldFact product or its “life-cycle process” intended to satisfy the requirements of the functional design respectively the requirements baseline.

Moreover the architectural design will show the system context of the FieldFact products being developed as well as their interfaces and embedding in the GALILEO architectural frame (see chapters 3.3 and 3.4).

1.2 Intended audience / Classification

The software architecture of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships between them. The term also refers to documentation of a system's software architecture. Documenting software architecture facilitates communication between stakeholders, documents early decisions about high-level design, and allows reuse of design components and patterns between projects [1].

The architectural model report will provide a clear view on the architecture to be used for the demonstrators and the driving requirements that have lead to the architecture.

The intended audience of this document is threefold:

Designers/developers in the FieldFact Work package 3 – Applications

The architectural design describes the components of the FieldFact architecture and their relationships, derived from the requirements and aiming at facilitating functionality defined earlier in the work of WP3. Thus, it will define the technical framework for the subsequent implementation of demonstrators.

Other FieldFact work packages

The architectural model report will provide other work packages with the necessary technical background information to understand the architecture as well as the major drivers that lead to the architectural model. Especially the work packages WP5 (Testing and Training) and WP6 (Promotion) will benefit. They can in an early stage get a good impression of the technical background of the demonstrator applications.

GSA

The architectural model report will provide a clear view on the architecture to be used for the demonstrators and the driving requirements that have lead to the architecture. GSA will be able to assess the fulfilment of relevant requirements into the demonstrator applications.

General Public



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This document describes the design of the architecture for the FieldFact demonstrator application. However, this document contains valuable information on the embedment of the FieldFact architecture in the Galileo / GNSS architecture. Besides, many aspects of the FieldFact architectural model can be useful in other application areas, either within of outside of the agricultural community.

Although this document was intended to be classified as a restricted document, the scope of the document and the usefulness of many aspects described in this document outside of the FieldFact project justifies a broader publication. This document is therefore classified PUBLIC.

1.3 Associated documentation

This list states the project documents that were used as input documents for the elaboration of this document:

- Report Requirement Identification and Priority, version 1.3, May 2007. Reference FIELDFACT-WP1-JRC-DEL-1.3
- Critical Analysis Report, The state and future of GNSS in Agriculture Europe 2007, version 1.0, May 2007. Reference FIELDFACT-WP2-EKO-DEL-2.1
- Requirements Report, Requirements and recommendations for GNSS demonstrators, spatial data use, training and promotion, version 2.1, April 2007. Reference FIELDFACT-WP2-EKO-DEL-2.3.
- Conceptual Modelling Report. Basis for Application Development, version 1.1, July 2007. Reference FIELDFACT-WP3-ALT-DEL-3.2.
- Geo-Spatial Data Issues. D.4.1; D.4.2; D.4.3 Integrated Report, version 1.1, September 2007. Reference FIELDFACT-WP4-VEX-DEL-4.1-3.

1.4 Reference Documentation

1. Len, B., Clements, P., Kazman, R. (2003): Software Architecture In Practice, Second Edition. Boston: Addison-Wesley.
2. ISO/IEC 42010:2007, Systems and Software Engineering -- Recommended practice for architectural description of software-intensive systems. (Note: ISO/IEC 42010:2007 was formally known as ANSI/IEEE 1471-2000, Recommended Practice for Architecture Description of Software-Intensive Systems.)
3. Internet: http://www.sei.cmu.edu/architecture/published_definitions.html#Modern (last access on Monday, 5th of Nov.2007).
4. Dunkel, J. Holitschke, A. (2003): Software Architecture (In. German), Springer Verlag.
5. Software Architectures.com: Internet, (last access Thursday, 8th of Nov. 2007): <http://www.softwarearchitectures.com/go/Discipline/DesigningArchitecture/QualityAttributes/tabid/64/Default.aspx>
6. Orfali, R., Harkey, D., Edwards, J., 1996: The Essential Client/Server Survival Guide. Second Edition. Wiley Computer Publishing, John Wiley & Sons, Inc, New York;
7. Hammerschall, U., 2005: Verteilte Systeme und Anwendungen: Architekturkonzepte, Standards und Middleware-Technologien. Pearson Studium, München.



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8. Internet: <http://www.orafaq.com/faqsdo.htm#WHAT> (last access on 15th of Nov. 2007).

1.5 Abbreviations and Acronyms

ANSI	American National Standards Institute.
CAP	Common Agricultural Policy
DOP	Digital Orthophoto
DSS	Decision Support System
EC	European Community
ECU	Electronic Control Unit
EDI	Electronic Data Interchange
EGNOS	European Geostationary Navigation Overlay Service
EU	European Union
FMS	Farm Management System
GCC	GALILEO Control Centers
GJU	GALILEO Joint Undertaking
GIS	Geographic Information System
GML	Geography Markup Language
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPX	GPS Exchange Format
GSA	GNSS Supervisory Authority
GSM	Global System for Mobile Communication
GSS	GALILEO Sensor Station
GUI	Graphical User Interface
GUS	GALILEO Up-link Stations
HTTP	HyperText Transfer Protocol
HTML	HyperText Markup Language
IEEE	Institute of Electrical and Electronics Engineers
ISOBUS	Open protocol for communication between electronic control units, based on the ISO11783 standard
J2EE	Java 2 Platform, Enterprise Edition
JDBC	Java Database Connectivity
JSP	Java Server Pages
ORDBMS	Object-Relational Database Management System



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LPIS	Land Parcel Identification System
MEO	Medium Earth Orbit
MUS	Mission Up-link Station
ODBC	Open Database Connectivity
OGC	Open Geospatial Consortium
PDA	Personal Digital Assistant
RDBMS	Relational Database Management System
RPC	Remote Procedure Call
RTK	Real Time Kinematics
SIS	Signal In Space
SQL	Structured Query Language
UMTS	Universal Mobile Telecommunication System
WFS	Web Feature Service
WMS	Web Map Service
XML	eXtended Markup Language

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2 DESCRIPTION OF THE WORK CARRIED OUT

2.1 Introduction

This chapter describes the background and motives used when developing the architectural model presented in this document and provides the relevant technical and scientific context. It also describes the methodology used to come to the architectural model.

There is a considerable amount of publications available regarding software- or system architecture. A profound compilation of literature can be found on the internet [3].

In principal the architecture of a software-system serves as fundamental description to understand or design a system. Thus rather the collaboration or interaction in terms of data and control-flows, constraints of conditions is necessary to be described than the understanding of the system parts it selves. Moreover the software architecture discipline is centred on the idea of reducing complexity through abstraction and separation of concerns.

According to the ANSI/IEEE Std 1471-2000 the term architecture is defined as the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution [2]. This definition is intended to encompass a variety of uses of the term architecture by recognizing their underlying common elements. Principal among these is the need to understand and control those elements of system design that capture the system's utility, cost, and risk. In some cases, these elements are the physical components of the system and their relationships. In other cases, these elements are not physical, but instead, logical components. In still other cases, these elements are enduring principles or patterns that create enduring organizational structures. The definition is intended to encompass these distinct, but related uses, while encouraging more rigorous definition of what constitutes the fundamental organization of a system within particular domains.

Dunkel & Holitschke 2003 [4] provide a compilation of characterizations of a software architecture that is more concise and so was supposed to better provide a structure of the report in the following chapter. According to the authors a software architecture:

- Determines the subordinate organization of the software-system with its principal structures.
- Defines the software-components of the system with its interfaces.
- The amount of software-components covers all functional and non-functional requirements that are defined by the requirements analysis.

The software architecture describes the dynamic behaviour of the system by determining the relations and interactions between the software-components.

2.2 Rationale

On the basis of the associated documents specified in paragraph 1.3 and taking into consideration some generic de-facto standards we have developed the FieldFact Architectural Model.

The conceptual model developed for the FieldFact project and documented in the Conceptual Modelling Report (FIELDFACT-WP3-ALT-DEL-3-2) forms another basis for the architectural model described in this report. In this report we have described 3 sub models: the FieldFact domain model, a model for spatial objects and a global technical architecture. Together these sub models describe a conceptual framework that fits the relevant aspects of the FieldFact domain. They have also been used as a starting point to develop the architectural model.



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The other bases for the elaboration of the architectural model were the functional and non-functional requirements as defined in the Requirements Report (FIELDFACT-WP2-EKO-DEL-2.3). We have taken into account the relevant requirements and translated these requirements into the FieldFact architectural design.

The last important input for the architectural model was the report on Geo-Spatial Data Issues (FIELDFACT-WP4-VEX-DEL-4.1-3) as reported as a result of the work package 4 activities. In this document the conditions and requirements concerning the use of spatial data are described. This document also proved to be very relevant when defining the architectural design, especially since the availability and use of geo-data is a crucial factor in GNSS applications and also standardization issues in this respect play an important role.

In order to be able to define the FieldFact architecture we have used an approach of stepwise refinement. We have taken the global architecture of the GALILEO infrastructure as the starting point of this process. From that starting point we isolated the “application segment” defined in that architecture, which is the global component in which the FieldFact architecture and the demonstrator applications to be developed within this architecture should be embedded. Putting the FieldFact demonstrator application in the center of the architecture, we have first defined the relevant interfaces around these applications and subsequently refined this application component into an architecture that is feasible to implement the foreseen FieldFact applications. Clearly, we have aimed at an architecture that is not only feasible for implementation of the FieldFact applications but can be applied to virtually all applications concerning the use of GNSS in agriculture.

After designing the architecture, we have verified the developed architectural model. In order to perform this verification, we have taken the functional and non-functional requirements that were defined in the Requirements Report and compared these to the characteristics of the architectural model. We performed the same activity on the relevant aspects that were mentioned in the report on Geo-Spatial Data Issues. The result of this action was that it can be concluded that virtually all relevant requirements are supported by the characteristics of the architectural model.

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3 RESULTS OF WORK CARRIED OUT

3.1 Introduction

This chapter describes the architectural model for the FieldFact demonstrators. In paragraph 3.2 an explanation is given of the overall architecture of the GALILEO GNSS. This is an important issue, because the architecture developed in the FieldFact project should be fit to be embedded into this overall GALILEO architecture. Subsequently, the FieldFact Application Segment, consisting of the FieldFact demonstrators and their interfaces with the “outside world” are depicted in paragraph 3.3. As a final step in the refinement towards an architectural model, in paragraph 3.4 the FieldFact application is further detailed, translating it into a technical architecture feasible for the implementation of the FieldFact demonstrators.

The design of this architectural model takes into account the requirements imposed by the Requirements Analysis elicited in WP2 and the requirements imposed by the Geo-Spatial Data Issues elaborated by WP4. In order to demonstrate that the architectural model is compliant with the relevant requirements for the FieldFact demonstrator, the final paragraph of this chapter describes which requirements have been taken into account and how they are covered by the architecture.

3.2 GALILEO Architectural Framework

The architectural design for the demonstrators to be developed within this project is to be embedded in the existing overall GALILEO architectural framework and represents a value add to this framework. This paragraph provides an overview of the system context in which the components to be used and developed are embedded.

In principal the GALILEO architecture is made up of three principal segments, a;

- Space Segment,
- Ground Segment and
- User or “Application” Segment.

Figure 1 depicts the components of the GALILEO architecture.

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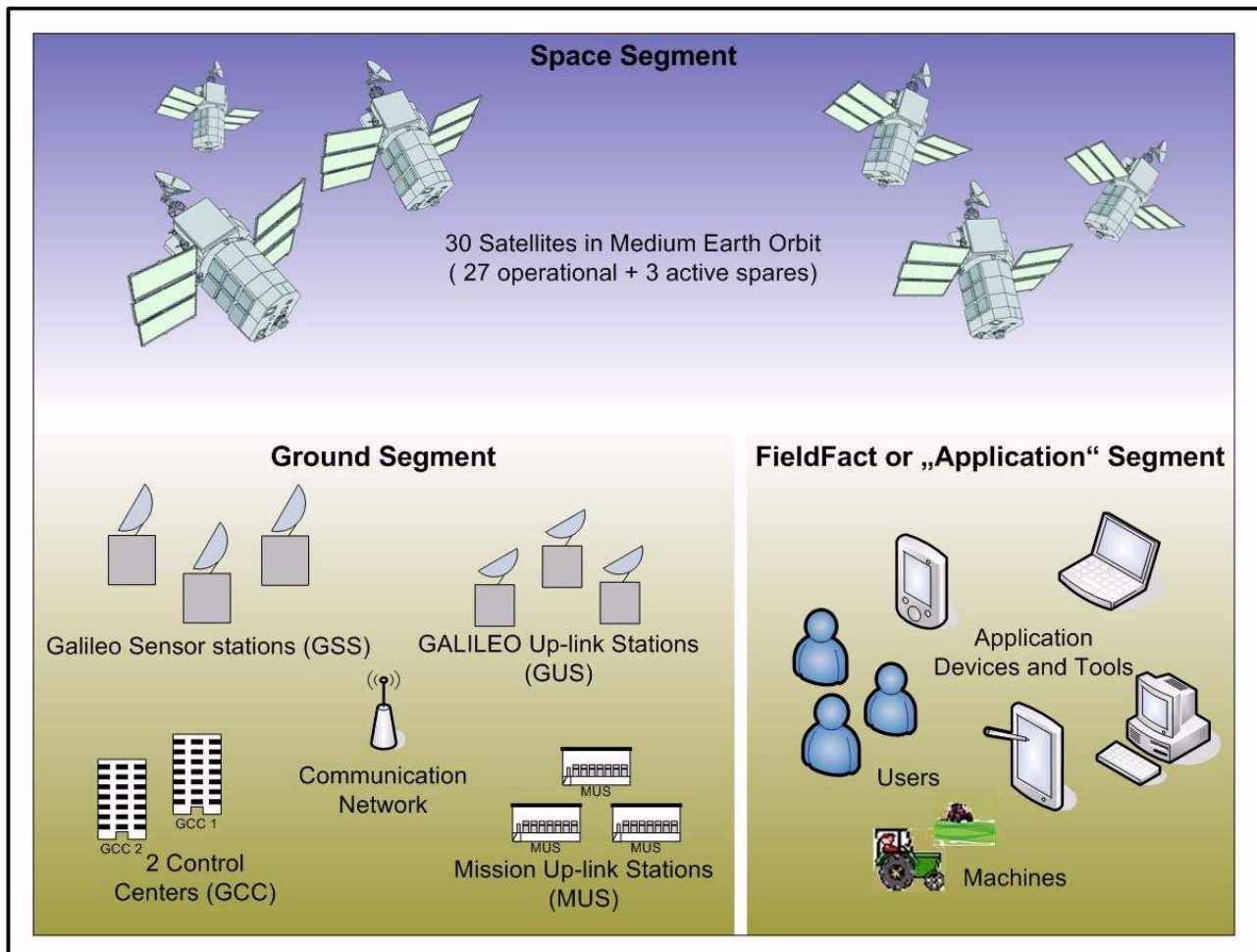


Figure 1: GALILEO architectural framework

3.2.1 The GALILEO Space Segment

The central component of the GALILEO architecture will be the global constellation of thirty satellites, distributed over three planes in Medium Earth Orbit (MEO). Within each plane, one satellite is an active spare, able to be moved to any of the other satellite positions within its plane, for replacement of a failed satellite.

The GALILEO Space Segment connects to the other segments through the Signal in Space (SIS). Regarding this SIS, the information on the Signal In Space quality, also called integrity information, is one of the major differentiators of GALILEO compared to other GNSS. Another differentiator is the possibility to make use of authenticated signals.

3.2.2 The GALILEO Ground Segment

The operation of the Space Segment is controlled and monitored through the GALILEO Ground Segment.

The control of the satellite constellation, the synchronization of the satellite atomic clocks, processing of the integrity signal, and data handling of all internal and external elements is



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performed by two redundant GALILEO Control Centers (GCC). Both of which will be located on European ground.

Data transfer to and from the satellites is performed through a global network of GALILEO Up-link Stations (GUS), each of which combines a Telemetry, Telecommand & Tracking Station and a Mission Up-link Station (MUS). Further MUSs complement the global up-link capabilities.

GALILEO Sensor Stations distributed around the globe sense the quality of the satellite navigation signal (Signal In Space). The information of these stations is transmitted through a redundant GALILEO Communications Network to the two GCCs. The ground segment contains an additional network of stations to oversee the integrity of the signals and a processing centre to provide this service. The integrity information will be transmitted globally together with the navigation signal and thus allows the GALILEO system to be certified for Safety-of-Life applications.

3.2.3 The GALILEO FieldFact (Application) Segment

The GALILEO Application Segment contains a world of applications being built around the usage of location based information provided by the GALILEO system. These applications are being used in different domains, varying from e.g. road transport to, in the case of FieldFact, agriculture. These applications are built around specific users, devices and machinery that operate in the domain and are tailored to that specific domain. Having agriculture as its application area, the FieldFact Application Segment will typically have farmers, agricultural contractors, governments and other stakeholders in this sector as users. Devices and machines include computers, laptops, PDA's but are partly domain specific (e.g. tractors, agricultural machinery etc.).

The FieldFact architectural model is fully located in this segment and represents the value-add for the GALILEO/EGNOS system with its domain tailored agriculture oriented applications. The FieldFact demonstrators are to be embedded in this Application Segment.

3.3 Components of the FieldFact Application Segment

In agricultural practice, almost all elementary processes are performed "in the field". A local component performs the farming process using existing information, combined with new data collected in the field. In GNSS enabled applications, the GNSS/GALILEO SIS is used to determine the position on a real-time basis. Nowadays many farmers have a Farm Management System (FMS) as an important aid to manage their farms. In a farm management system the information collected in the field is integrated with existing historical operational and reference datasets.

The FMS is currently the central component in the information flows on a farm. In the FMS administrative, operational and financial data on the farm's business processes is collected. Besides, through its functionality, the FMS is able to create added value from this data. The demand for information from government (e.g. public aid application and other legislation) and partners in the logistic chain (e.g. for quality control and certification) is getting higher. Thus, the exchange of information with external systems is an essential part of every farm management system.

Alternatively, data gathered by the local component might be submitted directly to an external system, like for instance a governmental database. In that special case, this system might also be looked upon as the "central component".

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The FieldFact application segment is characterised by coherent components being loosely coupled with each other. Each component offers a clear interface to the outside world and interacts with other components in a technical and also conceptual (or “semantic”) way.

The following figure depicts a generic (conceptual) architectural model of the FieldFact Application system including its relevant interfaces in the context of this project:

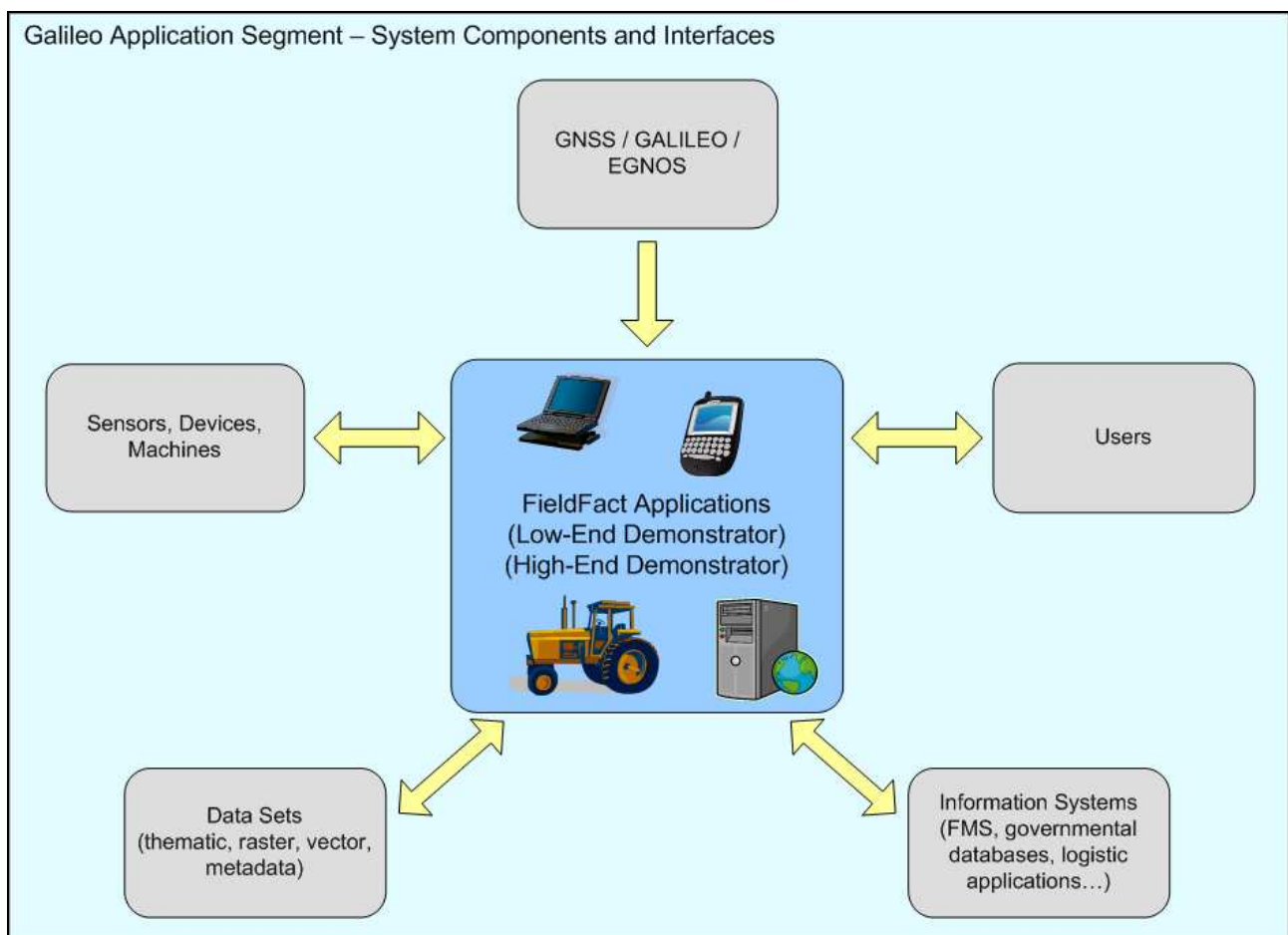


Figure 2: Components and interfaces of the FieldFact Application Segment

In the following paragraphs the individual components within the FieldFact Application Segment are described.

3.3.1 FieldFact Applications

The central component of the FieldFact Application Segment is the demonstrator component set, which is based on a distributed web-based client-server system. This system will be explained explicitly in chapter 3.4. The FieldFact applications have to be divided between a high end demonstrator and a low end demonstrator.

The low-end demonstrator uses a low-cost, mass-market, hand-held GNSS receiver integrated with a programmable environment, which could be used for activity registration and for parcel (area) measurements. It should further be aimed at a majority of European farmers, underline the added value of GALILEO services and create acceptance for GNSS technologies. The main

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objective of the low end demonstrator is to create awareness within the user community about the circumstances and conditions under which the GNSS signal can be used at farm and field level.

The high-end demonstrator is composed around a dedicated GNSS receiver integrated with sensors and machines. It will be built around a GIS and the integration of GNSS and other geo data sources through a central GIS . It will also be aimed at European farmers to underline the added value of GALILEO services and create acceptance for the GNSS technologies.

3.3.2 GNSS, GALILEO, EGNOS

The composition of the space and ground segments of the GALILEO system has already been described in paragraph 3.2. The interface of the FieldFact Application Segment with the global GALILEO system architecture consists of the GNSS signals provided by the GALILEO system. The GALILEO SIS offers through its SIS a number of differentiating characteristics that extend the application areas of GNSS in agriculture. It is in particular the utilisation of these differentiators that will characterise the applications in the FieldFact domain.

In addition to the signals provided by the GALILEO system, specific integrity uplink channels might extend the interface with the application segment.

3.3.3 Users

The users are the main and direct beneficiaries of the Application Segment. End-Users in the FieldFact domain are represented by farmers, representatives of farmers such as trustees or agents, contractors or even by governmental employees (e.g. controllers) that directly use the applications in the application segment. Furthermore, indirect users can be identified. One can think for example of governmental employees receiving application data that was accomplished by applications.

According to the Critical Analysis Report (FIELDFACT-WP2-EKO-DEL-2-1), three major groups of actors with regard to GNSS use can be identified:

- Farmers
- Professional service providers (e.g. contractors, farm advisory services, accountants, animal transporters, veterinarians, etc.)
- Public administration

A clear distinction should be made between the part of the agricultural community that is relevant for the whole of the Application Segment in Agriculture and the user community relevant for the FieldFact Application Segment. Since the FieldFact project aims at promotion through among others demonstrations and training, the users of the FieldFact Application Segment will be a limited number of members of the agricultural community (attending those demonstrations or trainings) and concurrent usage will be limited. Although it will not be compulsory in the first run for the FieldFact applications to cope with such an amount of users, the software design must be able to cope with such a dimension of users.

3.3.4 Data and knowledge

The added value of using GNSS positioning data lies mainly in the added value of the combination and integration of these collected datasets with other domain specific data sets and in the reuse of these data in (possibly other) applications and processes. Generally these datasets would be



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spatial datasets that will be used for reference (e.g. comparison of measured parcel data with parcels derived from a reference dataset) or for further elaboration. Locally collected positioning datasets can be combined with datasets from other sources (e.g. soil maps, yield maps etc.) using specific agronomic domain models to derive new knowledge and process information. Application can vary from the derivation of datasets for governmental control or for certification purposes to the generation of datasets that can be used as control information for machinery.

In geo-information sources we can separate between 3 types of geo-information:

Thematic geo-information datasets

This concerns thematic information with a spatial context. It concerns data that are not spatial data, but that are related to a spatial entity through references. A possible example is a table with the areas of arable land per administrative area. The records in such a table would refer to another object set, containing the spatial definition of the administrative areas in the form of a vector dataset.

Vector datasets

Vector layers are made up of many individual, scalable objects. These objects are defined by mathematical equations rather than pixels, so they always render at the highest quality. Objects may consist of lines, curves, and shapes with editable attributes such as crop types, sowing dates, ownerships, etc.

A good example of vector datasets in the FieldFact domain is parcel data. Parcel data are relevant as a reference dataset in virtually every possible application in the agricultural domain. As an example, farmers applying for CAP subsidies will deal with reference parcel information from the LPIS (Land Parcel Identification System) and with the parcel information they submit for subsidy application. Through the interface with the FieldFact application segment it should thus be possible to transfer for example the LPIS parcels into (for reference use) and out of the system (supplying updates to the LPIS parcels).

Raster datasets

A raster image file is generally defined to be a rectangular array of regularly sampled values, known as pixels. Each pixel (picture element) has one or more numbers associated with it, generally specifying a colour that the pixel should be displayed in. Raster images like aerial photographs or satellite images are mostly used to update the information present in a vector layer; e.g. changes in the parcel geometry, crop status, etc.

An example of a raster dataset to be used in the FieldFact Application Segment is digital orthophotos of the area of interest, providing an orientation layer on for example a PDA in the field. Raster datasets can also be the basis of control maps, providing control information to operate machinery in the field.

Metadata

These days, it is common practice to facilitate the registration of metadata related to the datasets used. Metadata is data about data and is used to facilitate the understanding, use and management of datasets. In the area of spatial information, metadata descriptions accompanying datasets allow for transparency with respect to origin, quality, projection, and related aspects. In the FieldFact project we will use the ISO 19115(:2003) standard, which is the commonly adhered standard for geospatial metadata (see also FIELDFACT-WP4-VEX-DEL-4-1-3). This standard exactly defines what information should be stored as metadata and the linked ISO 19139 standards stipulate how this information should be stored in an xml document.

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3.3.5 Farm-Management Systems

The FMS has become a central component of the modern farm. For most farmers the FMS has for a long time been a tool that was merely used to centralize and manage the farms operational, financial and legal administration. Administrative and financial information was registered in the system and reports for internal and external purposes were generated on demand.

In recent years the FMS has evolved from a purely administrative tool to a system that supports the decision making and the operational activities in the field. Wherever possible, data on operational activities are collected and stored in the FMS to be used again to generate new knowledge or operational control information. Agronomic models are starting to be introduced into these systems to support these processes.

An FMS typically exchanges data with other (including external) components using an EDI (Electronic Data Interchange) protocol. In recent years a lot of standardization work has been done on EDI data exchange protocols in the agricultural community. Well known examples of such standards are AgroXML and EDITEelt. The use of such a standard can thus be regarded as a major requirement for an FMS in order to comply with the common exchange standards in the agricultural sector.

3.3.6 Sensors, Devices, Machines

A large diversity of sensors, devices and machines is currently being used in the agricultural community, automating the various agricultural operations and processes and thus supporting farmers in on-farm activities. Tractors and machines are usually equipped with a board computer and through this board computer coupled with machines equipped with GNSS receivers, yield and other types of sensors. The processed signals are translated to the machine's/tractor's actuators, enabling automation of functionality like precision steering and driving or the control of spraying, seeding or fertilizing procedures in the field. Around the farm the modern farmer uses different IT devices to support his daily work and administration, varying from desktop computers for the FMS to mobile devices like laptops, PDA's and mobile phones.

Interfaces to and between different machines, sensors, actuators etc. will preferably be based on the ISOBUS standard. The ISOBUS protocol is an open protocol for communication between electronic control units (ECU's), based on the ISO11783 standard "Serial control and communications data network". It was derived to allow communication between and control of the various components composing the "on-field IT architecture" on a farm.

The communication between devices like PDA's, laptops and servers (both on-farm and between the farm and the out-side world) will preferably take place on the basis of eXtended Markup Language (XML) standards. Since it concerns data with a spatial component, the use of OpenGIS based standards like Geography Markup Language (GML) and GPS Exchange Format (GPX) is advisable. This also applies to the interfaces with the outside world, in this case the central component.

3.4 Architectural overview of the FieldFact Demonstrators

The demonstrator applications that will be developed in the framework of the FieldFact project should reflect a recognizable situation for the farmer and should be able to explain the added value of using GALILEO through the whole business process. Therefore, the architecture for the FieldFact demonstrators should clearly envisage the division in the subsystems described above.



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The architectural design for the FieldFact Application Segment consists of a set of components that are integrated in a loosely coupled way and interacting with each other through clearly defined interfaces. The next paragraphs give an overview on the systems components.

Figure 3 depicts a generic (conceptual) architectural design of the FieldFact Application Segment. It is based on a 3-tier architecture, leading to a separation of concerns between

- Presentation tier (graphic Interface (GUI))
- Application tier (main business logic) and
- Persistence-tier (data access and storage)

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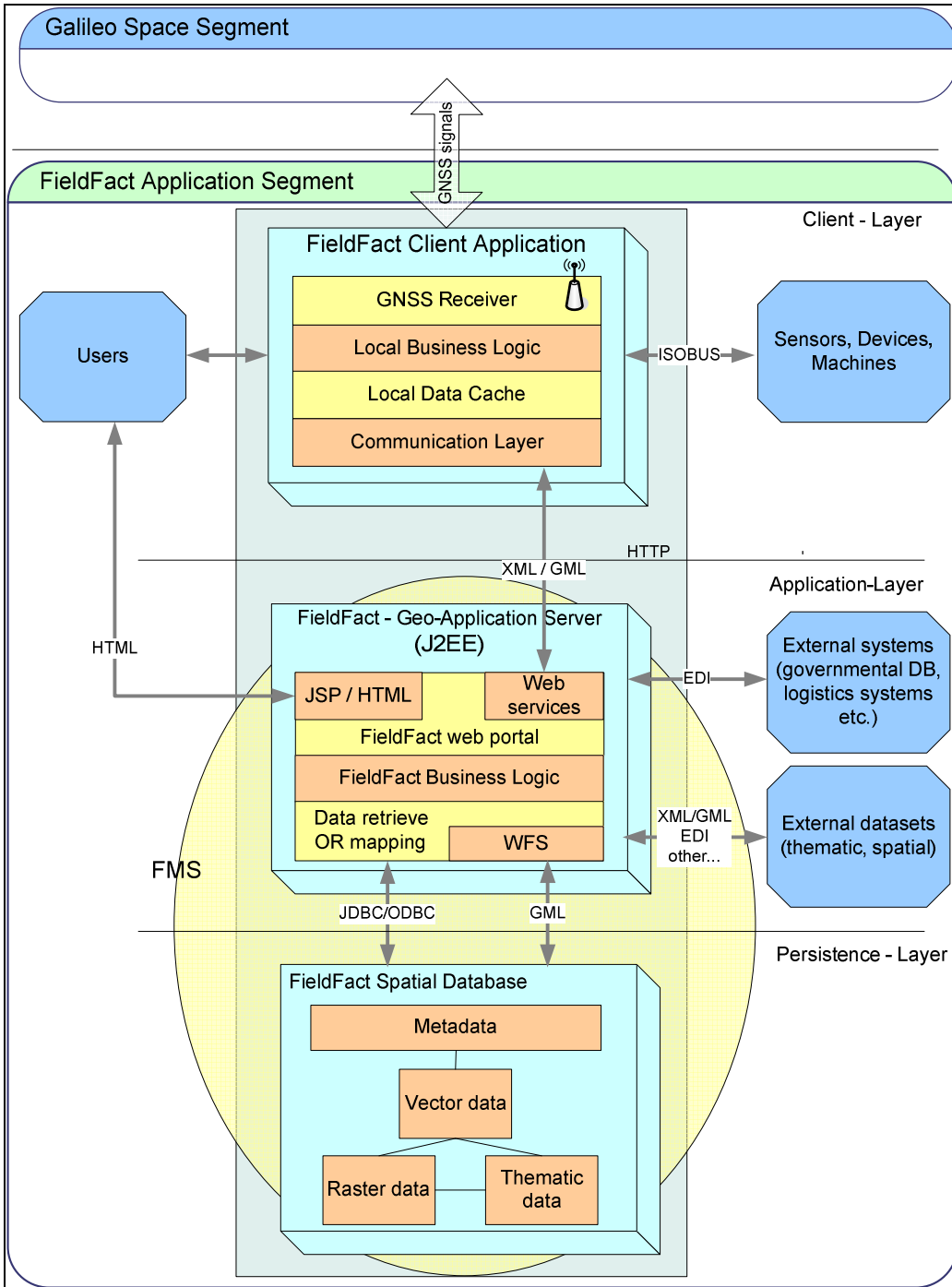


Figure 3: Overview of the FieldFact Application Segment

The architecture is derived from the commonly used 3-tier web-based client-server architecture. A web-based architecture is a special derivative of a client-server architecture. In this architecture, a distributed web-client sends requests to a web-server, which accepts, analyses and handles the requests, using business logic and finally delivers a result in the form of an HTML-document to the web-client. Data storage and data management is performed on a specialised tier.



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The three-tier model is considered to be a software architecture as well as a software design pattern and enables a distribution of the architectures components on different, distributed platforms. The architecture is mostly used when an effective distributed client/server design is needed that provides (when compared to the two tier) increased performance, flexibility, maintainability, reusability, and scalability, while hiding the complexity of distributed processing from the user. For detailed information on three-tier architectures see [6] and [7].

Apart from the usual advantages of modular software with well defined interfaces, the three-tier architecture is intended to allow any of the three tiers to be upgraded or replaced independently as requirements or technology change. For example, a change of operating system at the end user from Microsoft Windows to for example the Apple operating system would only affect the user interface code.

The presentation tier in a web-based architecture usually consists of a web-browser, likely a “universal-client” which is usually called a web-client and which implements the graphical user interface (GUI). In this architecture a web client typically communicates with the application tier through requests over the HTTP-protocol.

The application-tier (middle-tier) is positioned between the user interface (client) and the data management (server) components. This middle tier provides process management where business logic and rules are executed and can be scaled according to the amount of users and the resulting work load. It might provide functions such as authentication and authorisation, queuing, application execution, and database staging.

The persistence-tier provides data storage and database management functionality and is dedicated to data and file services that can be optimised without using any proprietary database management system languages. The data management component ensures that the data is consistent throughout the distributed environment through the use of features such as data locking, consistency, and replication. It should be noted that connectivity between tiers can be dynamically changed depending upon the user's request for data and services. [8]

Although being based on this 3-tier web-based architecture, due to the specific characteristics of the FieldFact Application Segment, the separation of concern between the tiers that is normally used in these architectures is not carried through that strictly in the architectural design presented in this chapter. The specific FieldFact components are described in more detail in the next three paragraphs (3.4.1 - 3.4.3). These paragraphs also describe how and explain why the FieldFact architecture does not fully implement the web-based 3-tier architecture.



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3.4.1 The FieldFact presentation tier

The presentation tier of the FieldFact architectural design incorporates the hard- and software used operationally in the field by the farmer. One of the important characteristics of applications that are used supporting the operational on-farm activities in the agricultural community is that they are usually intentionally designed to run independent of remote hard- and software. It is for example not common practice in the agricultural environment to have an on-line connection to the Internet in the field. It is not usual in the rural areas over Europe to have GPRS / UMTS coverage, so critical operational processes are usually not dependent on these kinds of infrastructures. Data transfer from devices or machines in the field to the application tier (in the farmers practice usually the FMS) and vice-versa therefore usually take place before or after the execution of the operational field process. This transfer might occur through HTTP over the Internet, but might also be performed through device or application specific interfaces. As an example, the transfer of machine control data from the FMS to the board computer on a tractor, usually takes place through the exchange of datasets on a memory-card.

Consequently, it is evident that a pure web-based architecture as described earlier in this chapter is in general not feasible in the agricultural domain. Most applications should be able to run independently in the field and will not have an on-line connection to other tiers. In order to be able to function, such applications will usually implement a specific subset of application logic as well as a local data-cache. This provides these applications with the necessary data and knowledge to be able to operate off-line. The local business logic component can be for instance the board computer controlling the machines connected to the tractor. It might also be a specific software component running on a device (PDA, laptop, smart phone) that processes the location based samples delivered by the receiver component, using specific domain knowledge and reference datasets. The datasets to be used will be pre-loaded from the application tier and will subsequently be available through the local data cache component. Location specific information relevant for the execution of the operational process is available from that cache. It might contain information on the dimensions of the parcel and parcel specific characteristics that are used by the local application logic to perform the operations. In most cases, the collected operational data, enriched with the spatial information from the receiver component and operational data measured by sensors and devices is stored in the local data cache be transferred to the application tier in a later stage in order to be re-used in the future.

Most modern devices and machines use known farm and field information to improve performance of the operation carried out in the field. Usually they are also equipped with sensors to measure and collect local data on a real-time basis. In the case of for example a machine, there will be actuators that are able to translate input data to actual execution of an operation on the field. Central in all local components is a “processor unit”, a combination of hard- and software that is able to exchange data with the outside world and to control both sensors and actuators. It performs local data processing in order to generate usable control information that can be used to steer the operational process. In the case of farming machinery this processor unit is usually an installed board computer. In the case of mobile applications this would be for instance a smart phone or PDA device.

Evidently for applications supporting GNSS / GALILEO, one of the critical “sensors” is the GALILEO enabled GNSS receiver that connects the FieldFact Application Segment to the GALILEO Space Segment. Mobile field applications might use either a built-in or external receiver. These mobile applications will typically be built around a software component that is able to read and interpret the receiver signal which is interfacing with a user-application built on the OS-platform of the specific device. GNSS receivers on farm machinery are usually tightly connected to the on-board computer that controls the execution of operations based on site specific instruction maps. In



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both cases the location and time data delivered by the GNSS system is integrated into the application flow on a real-time basis. Application software and GNSS receiver are again loosely coupled, meaning that a GPS/EGNOS enabled receiver could be replaced by a receiver supporting for example the GALILEO signal, without having to rewrite the application.

A communication layer component is implemented on the presentation tier as the interface connecting this tier to the application tier. Since interoperability and connectivity are important requirements for the demonstrators, it is important that these interfaces are designed based on commonly used standards in the agricultural community and preferably on open standards. The preferred format for data-exchange will be XML / GML over the HTTP protocol, preferably through web services. Web applications in this tier will be based on HTML/scripting, again transferred over HTTP. Consequently, the communication layer will either be the “back-end” of a web browser in the case of an HTML application, or a set of caller interfaces for the communication with web services on the application tier.

3.4.2 The FieldFact application tier

The FieldFact application tier is composed of a set of architectural components. As opposed to the presentation tier, the application tier does not differ a lot from the commonly known web-based 3-tier architecture.

The FieldFact web portal forms the “front-end” of the application tier infrastructure. It supports applications and users operating in the presentation tier in various ways:

- The web portal hosts a set of web-based applications that can directly be accessed by users through the Internet. Users can access these HTML-based applications through an Internet browser. To support this, the portal is implemented on a J2EE based infrastructure and serves functionality through Java Server Pages (JSP).
- The web portal implements a set of FieldFact web services. These web services form the interface between the application tier and the outside world. First of all, the communication between the presentation tier and the application tier relies on this web services interface. The aim of the FieldFact architectural design is that automated communication between the operational applications in the field and the application tier will be based on remote procedure calls through web services. In that case, the FieldFact application on the client tier will be the caller of one or more web services offering the requested data. Examples of such services are the retrieval of a reference map from the server or the submitting of collected data on the client to the server.

The FieldFact web portal will not only function as the interface with the application tier. It will also, through the same way of a combination of web services and HTML based functionality, support the interface to the outside world. Various standardised protocols for the exchange of information already mentioned before in this document will be used to access external datasets, to export data to the outside world or to communicate with external systems like for example governmental databases or applications provided by partners in the agricultural logistics chain.

The business logic component contains the business rules and agronomic models needed to fulfil the specific functional requirements of the FieldFact applications. In contrast to the limited set of application logic available in the presentation tier, which is oriented to the specific tasks to be performed in the field, the logic on the application tier is broader. It is oriented on tasks like the combination and integration of datasets, aimed at for example the generation of new information and knowledge.



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The business logic component also performs a number of “administrative tasks”. Among these tasks are authentication and authorisation, session management of user sessions, user management etc.

The data layer of the application tier supports the retrieval and storage of data from and to the persistence tier. This component provides object-relational mapping functionality to be able to translate application objects into (relational) database objects and vice-versa. Direct communication between application server and persistence tier is based on the commonly used Java Database Connectivity (JDBC)/Open Database Connectivity (ODBC) protocols.

Apart from this direct interface with the persistence tier, we will also extend the application tier with a web service based interface to the persistence tier. Many of the datasets to be exchanged between the tiers will be based on the Open Geospatial Consortium (OGC) standards and will thus be encoded in GML. With the implementation of a Web Feature Service (WFS) server as part of the application tier, a more direct interface for GML based datasets arises. Datasets originating from the presentation tier or from external systems that are transferred through GML can be directly inserted into a database available on the persistence tier through this WFS server. Vice-versa, the data from the FieldFact databases can be served to the outside world in a more direct way.

3.4.3 The FieldFact persistence-tier

The FieldFact persistence-tier provides database management functionality and is dedicated to data and file services that are optimized for spatial data storage and retrieval using a relational database management system (RDBMS) extended with a spatial component for spatial data storage and management. Implementing this object oriented spatial option the FieldFact RDBMS can be regarded as an Object Relational Database Management System (ORDBMS). The RDBMS component ensures that the data is consistent throughout the distributed environment through the use of features such as data locking, consistency, and replication.

The data to be stored in the persistence tier can be divided into the categories that have been discussed earlier in this document: thematic data, raster data, vector data and metadata. Using an RDBMS with a spatial extension, it is possible to store spatial information into the database. Points, lines and polygons can be integrated into the database design as (object) fields of database tables. Geographic and non-geographic datasets can thus be coupled, and datasets can be queried and stored using spatial extensions of query and programming languages available on the database platform.

3.4.4 The Farm Management System

As mentioned before, the demonstrator applications that will be developed in the framework of the FieldFact project should reflect a recognizable situation for the farmer. Considering the presented architecture, the application and the persistence tier represent the functionality that would in daily practice be part of the farmer’s FMS. From this point of view it is important to mention that, in general, the FMS on the market are also developing in the directions described in this architecture. Use of open standards, EDI standards, web services, Internet applications and the tendency to increase interoperability and connectivity are relevant tendencies in the agricultural community. Although farmers and other stakeholder might not be 100% familiar with the technical terminology, they will certainly be able to put demonstrators enabled on such architecture into that perspective.

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3.5 Compliance with FieldFact Requirements

This paragraph considers the specifications of the architectural design as described in the previous paragraphs and matches them with the requirements stated in the Requirements Report (FIELDFACT-WP2-EKO-DEL-2.3) and the report on Geo-Spatial Data Issues (FIELDFACT-WP4-VEX-DEL-4.1-3). The relevant characteristics of the architecture are listed and the requirements (coded with the same references as used in the Requirements Report) matching these characteristics are reported. Of course, not all requirements reported in the requirements report have a direct impact on the architectural design. Nevertheless, this paragraph will clarify and explain that the relevant requirements are covered with the presented architecture.

3.5.1 3-tier architecture

The presented 3-tier architecture provides a way of separation of concerns between the different tiers of the FieldFact architecture. The various facilities and functionalities needed in the system are divided over these tiers in a logical way. This separation of concern provides a loose coupling between relatively independent application components. The same component-based concept is used again to split the individual tiers into architectural components. In this way application functionality is split up in smaller components with dedicated functionality, which are easier to adapt and maintain.

Only to be able to deal with the specific characteristics of the FieldFact domain, it was decided to allow applications to implement a small local component for business logic and a local data cache as part of the presentation tier. This will allow applications to operate independently in agricultural environments, where continuous on-line connections to remote systems are not obvious.

Table 3-1 below describes how the 3-tier architecture supports the requirements of the FieldFact demonstrator applications.

Requirement. Id	Requirement	By
NFR-DEM-13	Demonstration of the end user part of the system can continue if problems occur in the coupling with server system (e.g. failing internet connection, no GPRS signal available).	Separation of concern through the use of a 3-tier architecture, combined with the fact that applications in the field are (if necessary) equipped with dedicated business logic and a local data cache makes the demonstrator applications rather insensitive to occasional problems occurring on the tiers.
NFR-DEM-25	The maximum time needed to process and aggregate collected data is 5 minutes.	Requests for processing of data collected in the field are initiated by the client application in the presentation tier. Since exchange occurs through a web services based Remote Procedure Call (RPC) mechanism, processing can be initiated on the application tier immediately. Subsequently, results can be returned to the client or can be published through the web portal.

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Requirement. Id	Requirement	By
NFR-DEM-30	Demonstrators are easily adaptable to different environments (e.g. different spatial data sets or formats of subsidy applications)	<p>In general, geographic and non-geographic datasets, templates etc. will all be stored and managed in the persistence tier independently. Integration functionality will be implemented in the business logic component and will use these independent datasets as inputs. Through this architecture, datasets and templates can be replaced by others very easily.</p> <p>Replacement of integration functionality, models etc on the application tier will also be possible without affecting the persistence tier.</p> <p>OpenGIS based software and a spatial RDBMS will support different coordinate systems and transitions between these systems, making it easy to make the software operational in areas with other coordinate systems.</p>
NFR-DEM-31	FieldFact demonstration configuration can be installed and configured within one working day.	Separation of concern over tiers, component based architecture and the use of open standards are all characteristics of the FieldFact architectural design that support installability and configurability of the system.
NFR-DEM-7	Demonstrators prevent an unauthorized access.	The application tier will be equipped with centralised and generic facilities to register users, authenticate users and authorize users.
NFR-DEM-9	Faults do not result in data loss.	<p>The local data cache available in the presentation tier facilitates the storage of temporary process information. This functionality will also be used to temporarily store process data between the moment of collection or generation and the moment of consolidation through the application tier into the persistence tier.</p> <p>The usage of an RBBMS with transaction support and recovery features as the basis for data storage and management will ensure that data loss on the server side is very unlikely.</p>

Table 3-1: Compliancy of 3-tier architecture with FieldFact demonstrator requirements

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The presented 3-tier architecture also matches with the FieldFact Spatial Data Infrastructure as presented in the report on Spatial Data Issues. Internal and external spatial data sets are served through distributed WMS/WFS services and can be integrated into the various components on the different tiers through the facilities available at the application tier.

3.5.2 Coupling with the GALILEO Space Segment

The FieldFact Application Segment is directly coupled with the GALILEO Space Segment and uses the positioning signals provided by GALILEO. At this point in time this means that the practical implementation of the coupling with the application segment is limited to EGNOS support on the common GPS signals (which nevertheless already increases the quality of the positioning data). In the future, the applications in the FieldFact domain can of course take advantage of the full set of GALILEO signals provided through the various services of the GALILEO system. In the meantime, in the FieldFact demonstrator applications we will use simulated integrity indicators to simulate, and to be able to explain the behaviour and advantages of the GALILEO Space Segment.

Table 3-2 describes how coupling with the GALILEO Space Segment supports the requirements of the FieldFact demonstrator applications.

Requirement. Id	Requirement	By
FRQ-DEM-1	User can always locate his/her current position...	GPS + EGNOS and in the future GALILEO + EGNOS provide accurate positioning information. Coupling and integration with spatial information sets on all tiers of the architecture will match operational data with reference datasets and create added value.
NFR-DEM-3	Demonstrators are interoperable with currently available GNSS (GPS and EGNOS).	Demonstrator applications are at this moment built to work with GPS and EGNOS.
FRQ-DEM-5	User will receive simulated integrity indicator.	Simulation of the GALILEO integrity features can demonstrate the value of an integrity signal that will become available as soon as GALILEO is operational.
FRQ-LED-8	User can measure a part of the boundary of selected LPIS parcel as a sequence of points. EGNOS corrections will be automatically activated...	GPS + EGNOS currently already provides accurate positioning information in FieldFact Application Segment

Table 3-2: Compliancy of GALILEO Space Segment coupling with FieldFact demonstrator requirements

3.5.3 Exchange of data and knowledge through open standards

The architecture of the FieldFact Application Segment is fundamentally designed to facilitate the exchange of information between the different tiers and among the interfacing component. Use of open standards supports the seamless exchange of information between components.



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Communication between FieldFact components and external components (e.g. machinery, web applications) can be realised fairly easy, because vendors of components in the application segment tend to comply with most of these open standards. It also facilitates software development in this application segment, since many components and libraries are available on the market and as open source software.

Some standards that are used in the FieldFact Application Domain are so commonly used throughout the "IT-world", that it is hardly necessary to mention them. Examples are the use of the HTTP protocol as a basis for communication on the Internet, or the use of the Structured Query Language (SQL) language and the ODBC protocol to query and communicate with databases.

The use of other (open) standards is not yet common practice in the agricultural community. Nevertheless, some of these standards are already well accepted and from the viewpoint of information exchange and integration essential elements in the FieldFact architectural design:

1. XML as a general format for data-exchange between components.
The XML standard has in the past years become a de facto standard for exchange of information, especially through the Internet.
2. The use of web services as a means of communication between applications or application components
Web services are developing as a common means to realize a communication infrastructure over the Internet. In many cases, the information that is exchanged through these web services is formatted as XML.
3. OpenGIS standards as a ways to format and exchange data with a spatial component
The OGC has developed a series of standards for the formatting and exchange of spatial information. GML is the standard for the notation of spatial information (or rather information that contains spatial elements) in XML. WMS and WFS are standards for the publication and exchange of spatial information. WMS provides a way to serve spatial information as maps to users / application on the Internet. WFS is a standard protocol for the exchange of spatial datasets. Both WMS and WFS standards are based on GML and on web services as a way of requesting and exchanging information.
4. The ISOBUS protocol as the communication protocol between automated components in the agricultural business.
The ISOBUS protocol is an open protocol for communication between electronic control units (ECU's), based on the ISO11783 standard "Serial control and communications data network". It was derived as a simplification/specialization of this protocol to allow communication between and control of the various components composing the technical IT architecture in the agricultural sector. Most vendors of tractors, board computers, machinery and farm management systems are currently compliant with this protocol.
5. National or international EDI standards in the agri-business for exchange of information through the production chain
National and international EDI standards are now in place to support the information exchange between parties in the agricultural production chain. These standards are usually broader than just the farm-related information domain and can cover also logistical information etc. Examples of such well-known standards are Agro-XML (international) and EDITEelt (The Netherlands).
6. Metadata standards
The commonly adhered standard for geospatial metadata is the ISO 19115(:2003) standard. We will use this standard to record metadata on the datasets used in the FieldFact project.

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Table 3-3 describes how the exchange of data through open standards supports the requirements of the FieldFact demonstrator applications.

Requirement. Id	Requirement	By
FRQ-HED-13	During movement of the machine the system registers position and automatically sets application rates	The usage of open standards will facilitate this. The ISOBUS protocol facilitates the necessary exchange of control information between FMS, board computer and machinery.
FRQ-HED-14	System registers the movement of the machine and the actual applied rate, which can be visualized and displayed in a map	The usage of open standards will facilitate this. The ISOBUS protocol facilitates the necessary exchange of collected local datasets between machinery, board computer and FMS. EDI standards will allow integration and exchange of application maps between components
FRQ-HED-17	During the movement of the machine the system can automatically set the corresponding application rate after crossing the boundary of simulated spatial zone	The usage of open standards will facilitate this. The ISOBUS protocol facilitates the necessary exchange of collected local datasets between machinery, board computer and FMS.
FRQ-HED-18	User can transfer collected data on machine movement and variable rate application to the sample farm management system (FMS) environment.	EDI standards will allow integration and exchange of application maps between client and the FMS
FRQ-HED-19	User can transfer collected data on parcel measurement to the sample farm management system (FMS) environment or governmental database.	
NFR-DEM-4	Demonstrators are interoperable with related external systems.	The usage of open standards will facilitate this. External systems will most likely comply with accepted EDI standards. Exchange will be based more and more on XML and OpenGIS standards for exchange of (geo-) information and will usually be transmitted over an HTTP connection.
NFR-DEM-5	Demonstrators comply with relevant technical standards for data representation and exchange.	

Table 3-3: Compliancy of data exchange through open standards with FieldFact demonstrator requirements

The report on Spatial Data Issues, among other things, focuses on the importance of using (open) standards when working with spatial data and spatial data infrastructures. The report states that standardisation of spatial data is an important prerequisite for an application where multiple data



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sources are combined and used in combination with location-based applications or GNSS in the agri-business sector. The standards used in the architectural design presented in this document are almost literally equal to the standards of importance mentioned in the report on Spatial Data Issues.

3.5.4 Integration of spatial and non-spatial datasets and domain knowledge

The FieldFact architecture aims at the integration of datasets and knowledge in many ways. The possibility to exchange data through open standards, mentioned above, is an important condition to be able to collect and bring together data and knowledge from different sources.

Implementation of business logic (mainly in the application tier, but if necessary also in the presentation tier) offers the functionality to combine datasets from various sources and subsequently integrate these datasets using knowledge rules, agronomic models etc. Thus, data can be pre-processed in the field and integrated with available data sources on the client tier, where data from the field, from the “local” database in the persistence tier and from external information sources comes together.

Using a spatial database in the persistence tier makes it possible to store and retrieve these datasets that often have a spatial component.

Table 3-4 describes how integration of spatial and non-spatial datasets and domain knowledge supports the requirements of the FieldFact demonstrator applications.

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Requirement. Id	Requirement	By
FRQ-DEM-2	User can view, combine and integrate various available spatial datasets...	Coupling and integration of spatial information sets and agronomic models through all tiers of the architecture allows exchange over tiers to the client application, and combination and integration of internal and external data sources on the client application
FRQ-DEM-6 FRQ-LED-7 FRQ-LED-11 FRQ-HED-15	Various requirements on the printing of integrated data and integration of dataset into e.g. a digital subsidy form.	Data to be printed can be retrieved from all tiers and can be combined and integrated with e.g. form templates on the application tier.
FRQ-HED-12	Recommendation map and corresponding application map are integrated in the demonstrator	Coupling with spatial information sets and agronomic models through all tiers of the architecture allows exchange over tiers, and combination and integration of internal and external data sources
FRQ-HED-14	System registers the movement of the machine and the actual applied rate, which can be visualized and displayed in a map	Locally processed application datasets can be combined and integrated with other (reference) datasets, e.g. parcel data or yield maps on the client application through the use of the local data cache and local business logic or on the application tier (e.g. by visualization of results through a web portal application)
FRQ-HED-16	Simulated spatial data on environmental zoning can be integrated in the system, viewed and combined with other available spatial data...	

Table 3-4: Compliancy of integration of spatial and non-spatial datasets and domain knowledge with FieldFact demonstrator requirements



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4 CONCLUSIONS & RECOMMENDATIONS

4.1 Conclusions

As a part of the task functional and non-functional analysis an architectural model has been developed. The result, which is recorded in this document, describes the architectural design of the FieldFact Application Segment as a specific elaboration of the “Application Segment” of the general GALILEO architecture.

In order to be able to define the FieldFact architecture we have used an approach of stepwise refinement. We have taken the global architecture of the GALILEO infrastructure as the starting point of this process. From that starting point we have isolated the “application segment” defined in that architecture, which is the global component in which the FieldFact architecture and the demonstrator applications to be developed within this architecture should be embedded. Putting the FieldFact demonstrator application in the centre of the architecture, we first defined the relevant interfaces around these applications and subsequently refined this application component into an architecture that is feasible for implementing the foreseen FieldFact applications. Clearly, we have aimed at an architecture that is not only feasible for implementation of the FieldFact applications but can be applied to virtually all applications concerning the use of GNSS in agriculture.

After the elaboration of the architectural design, we have performed a verification on it. In order to verify the design, we have taken the functional and non-functional requirements that were defined in the Requirements Report and compared these to the characteristics of the architectural model. We performed the same activity on the relevant aspects that were mentioned in the report on Geo-Spatial Data Issues. The result of this action was that it can be concluded that all relevant requirements are supported by the characteristics of the architectural model.

The main products of this activity are:

- An architectural model of the FieldFact Application Segment.
Defining an architectural design specifically directed to support the development of the FieldFact demonstrator applications.
- Compliance analysis
The compliance of specifications with the requirements as defined in the Requirements Report (ref: FIELDFACT-WP2-EKO-DEL-2.3) and the report on Geo-Spatial Data Issues (FIELDFACT-WP4-VEX-DEL-4.1-3) have been investigated and reported.

4.2 Recommendations

It is recommended that the FieldFact demonstrators will be based upon the architectural design as defined in this document. Adopting this architectural model will ensure that the demonstrator applications are based on a framework that fits the needs of the agricultural community in general and especially the FieldFact project.



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