AGRICULTURAL ICT INFRASTRUCTUE – ALSO REQUISITE FOR PRECISION FARMING

The map - supported by new NPK-sensors - is intelligent, not the tractor

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ABSTRACT

Many calculations done during the last two years showed that agriculture ICT infrastructure is a prerequisite for many agricultural needs of the summary of stakeholders within a country and it is also prerequisite for precision farming to get it at lowest costs as possible. What do we mean by the term "Agro-ICT-Infrastructure":

High resolution 30cm ortho-images – e.g. Microsoft Bing™ Maps as they are available for the entire US, for Western Europe and more is coming – everybody needs them for planning and control.

Next is the set-up of a cultivation register (Land Parcel Information System) as done within the EC, first for subsidies, now for many different needs (PROGIS did it for WinGIS™),

A rural Open Street Map (OSM) integrated into a GIS and routing software (WinGIS does it).

A farm-management and/or farm advisory (extension-) service-system that is linked to a regional or country-wide statistical system (we have done it with DokuPlant™ application).

Logistic applications to support farmers as well as chain partners, the industry, for any just in time delivery need (we have done it with our logistic system incl. mobGIS™ to be used on mobile equipment) to send contracts directly to a machine.

The installation of an agro-weather-sensor network – weather stations and soil sensors as decision guidance (we have in Austria two suppliers and cooperate intensively with them).

Precision farming is for me also everything said above but is mainly understood only as optimized fertilisation, pesticide use, harvest maps etc.; it is wonderful that we can drive cm-precise but we also should have soil data in the same precision – a missing link. NPK sensors will help! Nevertheless the key question is who will do all these services - soil analysis, interpretation, create fertilisation map that - on top of a contract, see logistics before – are sent to mobile devises that trigger a machine or guide drivers of elder equipment.

On top applications for more needs like land consolidation, environment management, carbon calculation, risk-management etc. incl. consulting can perfect the offer and will enable farmers becoming part of environmental-, risk-caretaking – above GAP compensated!

Intelligent business-models enable the owner of an Agro-ICT-infrastructure – public or private or ppp - to receive Return of Invest (ROI) supporting other stakeholders that will also benefit from the infrastructure as there are: banks, insurance companies, large farms, large forest enterprises, chain partners like food-industry, suppliers of farm equipment, agro-chemistry and agro-resources as well as international investors into agriculture and forestry.

The above costs are less than one $ per ha – but you must think big!

Keywords: precision agriculture, NPK-sensor, AGRO-infrastructure, GIS, maps

The implementation of this agro-ICT-backbone has to be realized within a large scale project together with a range of local partners and experts and is divided into following steps:

1) Production of **30cm orthoimages** with the digital surface model with 1,5 m resolution and a 60 cm infrared image. In the entire US done and available from Microsoft.

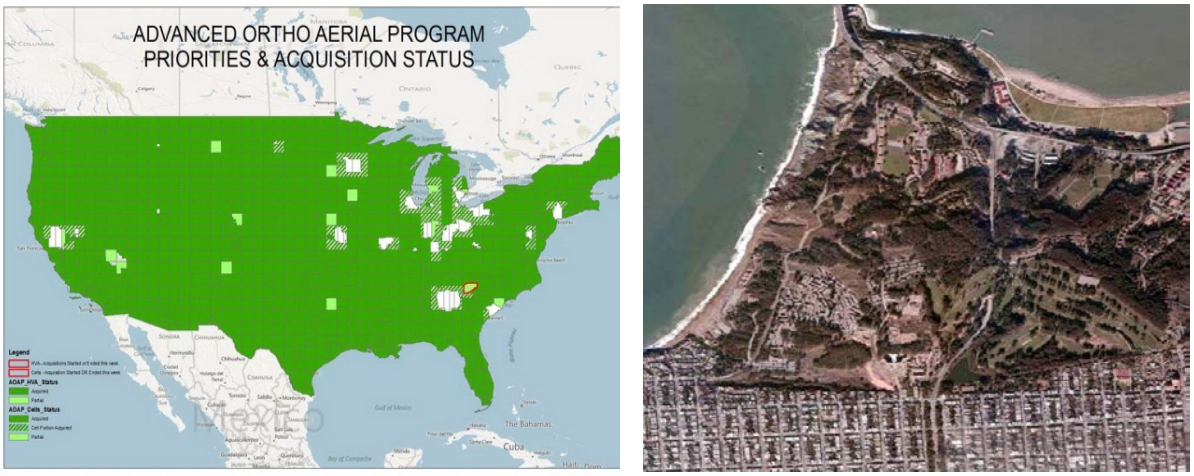

Fig. 1. BING acquisition with sample

2) Preparation of **LPIS (Land Parcel Information System).** The first mission is the implementation of GIS system (WinGIS) and set-up with it and the images the LPIS- or cultivation-register; digitize all fields and other land plots including the owner or the user of the plot to build up a countrywide land parcel database. An Open Street Map technology can be integrated. PROGIS` WinGIS is an easy to use, easy to learn, powerful and cost efficient GIS software with extensive geographic application possibilities and facilities.

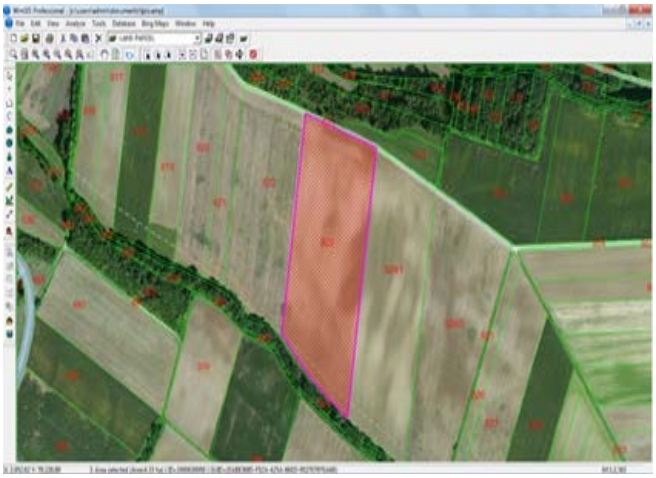

Fig. 2. Land parcel map

Due to the integration of the online map data of Microsoft Bing Maps as „embedded Module“, the access to worldwide available geographic data like satellite and aerial images, road maps and address databases is already part of the software package. The WinGIS import and export interfaces support the most common GIS/CAD file formats like the ESRI™ shape files, the AutoCAD™ DXF, MapInfo´™ MIF and also text based file formats like CSV or GPX for data import from e.g. GPS devices. In a few steps external spatial data can loaded into the users WinGIS project. Imported attribute data are stored in the internal database module of WinGIS.

By using the ActiveX developer component, application developers use the possibility to link their application to WinGIS in order to visualize, edit and administrate any data with a geographic relation. This is relevant for realizing suggestions from on-top consulting.

3) **Farm Management:** Implementation of the farm management (FMIS) resp. farm advisory service system DokuPlant™ for the daily management of extension services. The system has as fundament the GIS-based local LPIS, an integrated expert database (with all relevant agricultural data and cultivation recommendations supported by local partners) and a perpetual documentation tool. With this FMIS tools extension officers are enabled to do planning and control for every field, for a farm or for a region of many farms or when summarized to a system towards the Ministry for the whole country. Following information will be generated from every field and can be accumulated for the whole country:

- Activity management, Crop rotation, Cost calculation, Nutrient balance, Carbon balance, all input/resource needs, harvest estimations, ….

PC-*GIS*, ***real-time management*** and the ***expert-data base*** are integrated.

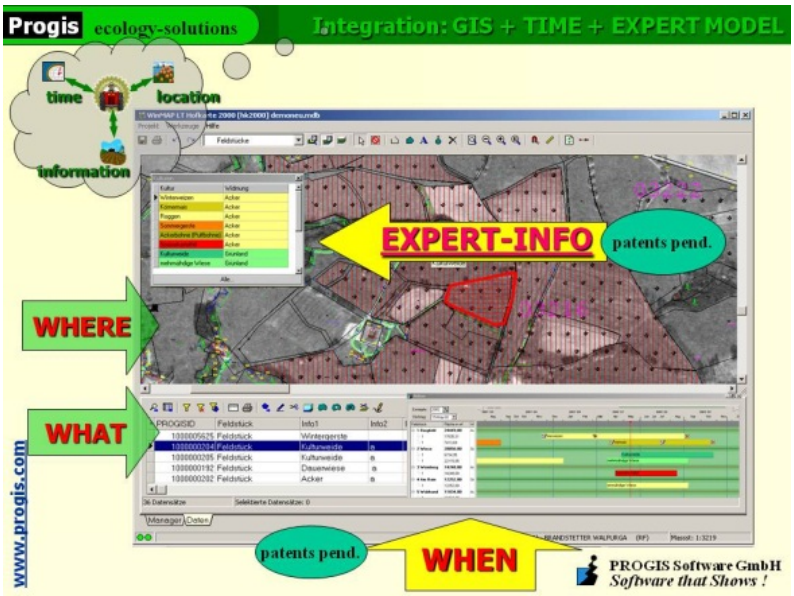

Fig. 3. Land- and farm management

The mapping of plots/fields is supported and a perpetual calendar enables the display of any performed activity: ***what – when - where***. The integrated database is filled with agro *expert data*, generated in close cooperation with <u>local</u> agro-forest-environmental scientists/experts - contains 2.500 agro-machine data (KTBL, costs, time, …), data on thousands mineral-/organic-fertilizers, 850 herbicides with contents, crops incl. varieties and 400 plants with average yield and seed needs. The ***complete working process*** for a year with all activities and relevant data is predefined for all crops and enables planning with one click: Where (plot in the map) do I plan what (select crop from the expert data bank). Individual farmers can modify the expert data at any time. DokuPlant manages **documentation** (food traceability), **nutrient-/energy-CO_2 balances** (fields/farms), **cost calculations** and **maps** and assist **subsidy** applications if locally needed.

4) **<u>Logistics:</u>** Logistic needs for group of farmers/foresters/industries will be generated on base of accumulated data from FMIS (see above). Process and time optimizations, where to deliver what" or "where to pick up what and when" and how to come to that location (with the help of the rural Open Street Map (rOSM)) will be realized.

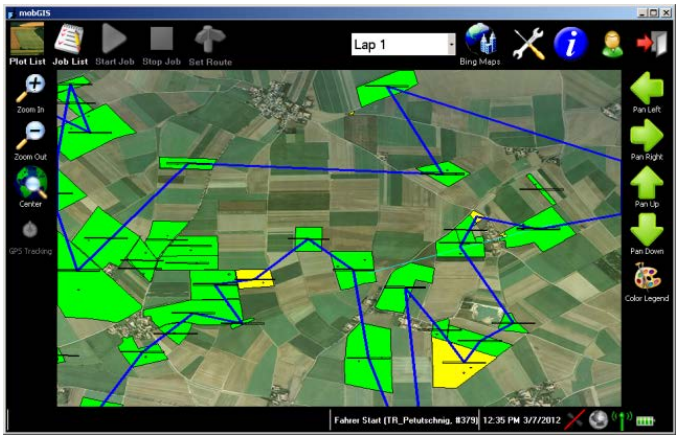

Fig. 4. Logistics mobGIS™ screen shot

The systems leads to an optimization of daily and seasonal routing, accurate information of harvest status, GPS position data visualization, online two-way communication between central and mobile terminals and order processing is supported. The software consists of a GIS central station and any number of mobile units ("mobGIS"), integrating GIS, communication (GPRS/UMTS) and GPS. It handles crops for food/feed or biomass production, liquid manure deposits, forest harvesting or any other logistic task. Up to 30 % cost reductions or more could be achieved.

5) **Agro-sensor-station:** A network of weather stations - one station for every microclimate - and soil moisture sensors is needed. Experts can, based on the data and a tool-set provide farmers with tailor made recommendations (e.g. forecasts for weather situations) but also get protocols of the situation of the past and the impact for the future – mass reproduction of a fungi or a beetle. The expert models have, based on existing know how that is trained and transferred, also to be adjusted or developed and fine-tuned from e.g. local phytopathology experts. With the soil moisture sensors all necessary data for irrigation can be collected.

Fig. 5. Agro-sensor-network

6) **Local infrastructure:** A prerequisite to start is a local infrastructure comprising local hardware, communication technologies and the whole appropriate personnel organizational structures. It contains the hard- and software for aggregation of the data at the Ministry of Agriculture, the countrywide structure for LPIS and FAS (Farm Advisory System), the mobile solutions and the communication layout. Local partners are integrated.

7) **Following further applications are available:**

a. **ForestOffice**: Deals with sustainable forestry planning, forest facilities, forest management and forest logistics; the expert data bank contains local growth tables
b. New concepts for **environment- and risk management** have been developed in cooperation with the University of Natural Resources, Vienna and are base for new land management. They deal with biodiversity, sustainability, multipurpose use of land and economic advantages, based on reliable criteria which have to become part of sustainable economics.
c. The **land consolidation module "Z-GIS"** was developed together with the Lower Austrian Government and allows an optimized land consolidation based on clear concepts and values as managed in Austria since 150 years.
Groundbook, cadaster, soilmaps and geodesy support new and optimized agricultural structures.

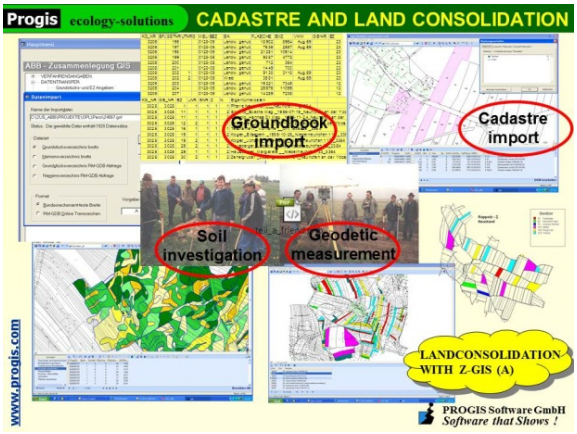

Fig. 6. land consolidation, cadastre

d. **Community- and pipeline-management** (water, wastewater) applications are also available for cooperation with partners and round off the portfolio for complete software for rural area management.

e. **On top consulting:** Additionally to the technology, consulting can be offered for above and also below topics. The consultants are best educated researchers, scientists and practitioners with long lasting experience and international reputation. The covered fields are: natural resource-, environment- and risk management, REDD+ projects and management, natural hazard and risk reduction management, wild-life management, natural parks, hunting, fishing, agro-forestry, nature conservation, eco-tourism, rural development etc., logistic, infrastructures for rural areas, carbon modeling and technology enabling carbon financing for complete countries, livestock and nutrient use for animals and the impact on fields, cooperative structures and their setup, Machine Cooperatives, inventory methods, forest management, precision farming, land consolidation, cloud based trust center, desertification (technology influencing drought, rainfall).

NPK microsensors – Macronutrient Nitrogen, Phosphorous, Potassium sensor for effective fertilizer management,
durable, with increased accuracy, stable NPK chemical micro-sensors suitable for PF

The NPK sensor – general concept:
Together with SEA partners we can offer an NPK sensor integrated with WinGIS. It works either manually and gives after 15 seconds values or can be integrated into farm equipment, e.g. ploughs where the system automatically produces NPK values and automatically an NPK map is developed. Beside NPK also temperature-, humidity-, pH- and moisture sensors are available. Details for detection range, sensitivity, operating temperature, operating humidity, response time, calibration requirement and costs can be transferred to interested parties on request.

NPK Microsensors

The use of micro-sensors for in-field monitoring of environmental parameters is of great interest, particularly semiconductor-based micro-sensors, due to their many advantages over conventional sensors such as small size, robustness, low output impedance and rapid response. They can further be integrated in circuitry and multiple sensors in the same substrate and accordingly they can be implemented in compact probes for particular applications e.g., in situ monitoring, or on-line or on-the-go measurements.
The sensors are using Ion Selective Field Effect Transistors (ISFETs) based micro-sensors, for environmental applications and are helpful for measuring primary macronutrients in soil.
Selected target ions include potassium, phosphate and nitrates. Required samples are in small volumes and such sensors can be integrated in compact flow cells for continuous measurements.
NPK micro-sensors are enabling precision agriculture to assist in (1) spatial data collection, (2) precision irrigation, (3) variable-rate technology (automated fertiliser) and (4) supplying data to farmers.

Competitive Advantage

At NPK micro-sensors for precision agriculture the cost of each sensor needs to be low and the stability of the sensor membrane needs to be high, especially when such sensor deployed harsh environments; furthermore the sensitivity needs to be high, and they also need to be supported by robust data management systems to be able to collect the data, manipulate it for decision support analysis in fertilizer management.

The benefits of the wireless sensor network platform invention, compared to traditional industry standard technologies are:

- Longer membrane lifetime, and durability;
- Increased sensitivity
- Increased platform flexibility (easily reconfigurable) that with minor hardware changes different parameters can be monitored.

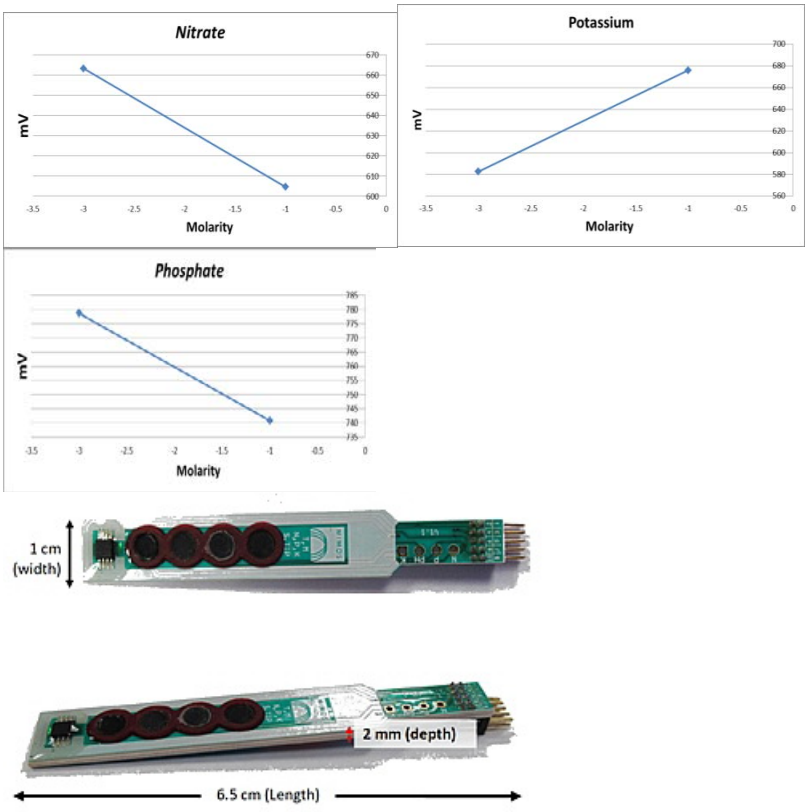

Fig. 7. NPK-sensor

The beneficiaries

In general – much of the information prepared by the agricultural ICT backbone can be used by several stakeholders and will be a benefit for several businesses. It means chain-partners will be ready to pay to get access to the information! The model in detail has to be worked out together with local structures and representatives from different stakeholders!

A public-private used ICT infrastructure, consisting of new ortho-images for the country covering GIS and IT solutions for rural area management in connection with land-management and extension-services, agriculture management and logistics can be used by different governmental organizations and can also be used by private structures and is:

- Supporting the **Minister of Agriculture** for his needs to organize subsidies,
- Supporting the Minister responsible for landscape changes, for cadaster, ground tax
- Supporting **consultants** in their advisory work
- Supporting **food chain partners** for traceability and for the documentation
- Supporting **logistic** service experts to do the right actions at the right field to find the right roads to the field and be there at the right time as well as deliver goods to the food industry "just in time"; it is a support to all **suppliers and buyers** of farm goods
- Supporting the **agro control** organization for subsidies
- Supporting the **bankers** to get a business-plan to be able to finance better
- Supporting the **insurance company** to make policies for the crops on the fields
- Supporting **ecology experts** or also **natural-risk-managers**
- Supporting the **human medicine** experts to judge the influence of food and environment on health
- Supporting last but not least the **farmer** to give him tools for his needs

To all mentioned groups the ICT-backbone can produce valuable services. For these services lots of ROI-money could be acquired but stays a political decision. (ROI calculations for single sectors can be done on request).

Naturally also a model is imaginable, where public (MOA) and private (banks, insurance, investors) share the investment and setup a Joint Venture.

The benefits on a Macro-economic level:

- **Import substitution** due to higher production within the country
- **Increased value of the farmers land** due to higher productivity and clear ownership situation and in summary **an increased value of the entire country**
- Fundament for *local carbon financing* projects is set up and a **countrywide carbon model can** be implemented with the help of the World-Bank or other related organizations
- **Increased income** for the smallholders, better living standards, more sustainable agriculture and a higher percentage of the agriculture to the GNP

- **Investors** will benefit from such an ICT backbone and the value of the land will also parallel increase due to better "packaging"
- **Extension services** will work better and administration will be able to optimize control
- **Cooperation between farmers and scientists** will be increased, easier implementation of cooperatives will change agricultural structures in a country with positive effects. Cooperation models due to shared use of the ICT backbone with other stakeholders within the agro-chain will reduce the costs and have impact on the budget
- **Banks and insurance** can be integrated and will directly or indirectly benefits from such an ICT structure and get the tools to start banking and insurance for smallholders
- Farmers get **better education** and can be guided into the direction of an **ECO-SOCIAL MARKET ECONOMY** and will based on good and sustainable management also have impact with their work towards ecological- and natural-risk-factors and will with this momentum taking part to reduce costs due to the fact "A stitch in time saves nine".

The benefits on a Micro-economic level:

- GIS (geographic information system) gives detailed information on **size and location of fields** of single/group of farms. This information is the base for ALL further planning incl. calculation and logistics.
- Farm management tools allow **cultivation planning, documentation** (also GLOBALGAP), time related **traceability, nutrient- and CO_2-balance, cost calculations,** control and provide information for trust centers.
- Farm management tools enable the setup of **farm advisory services**, provide them with all necessary information and integrate local know how.
- **Logistic solutions** with central and mobile GIS systems allow precise planning of all logistic needs in regions and serves farmers, food-industries, contractors and the environment and will lead to enormous cost savings.
- **Agro-meteorology data and soil moisture data** allow better decisions based on integrated local expertise.
- **Risk management** solution are for reducing the risk on water situation, erosions, fauna-flora-habitat optimization with carrying capacity, plant protection, food and feed safety etc.; solutions can help to better define and measure farmer's integration into environmental caretaking.
- **Business-plans** assist in cooperation with banks and insurance companies.
- **Machine interfaces** allow the set-up of precision or virtual farming solutions for groups of users, further statistical analysis for regions or countries and a possible

- **Forestry- and/or environmental-caretaking** solutions are supported.
- ICT will support the **fast distribution of scientific know how**, and an organized feedback will allow to verify and optimize results over the time!
- ICT will enable farmers to become **part of** decisions and implementation of **environmental caretaking** based on defined targets of beneficiaries, defined work plans and returns for farmers
- **Horizontal and vertical integration -** as the farmer is in many cases not working alone but in cooperation with neighbors or in cooperatives, an intelligent ICT solution has also to reflect the so called group needs and the integration of the farm management system or parts of it into these group needs. Naturally large farms can be seen as "one owner of horizontal integrated fields". Small farms will be integrated and benefit from these new and exciting technologies with the help of service providers supporting the farm management but also the horizontal and vertical ICT needs.
- **Land consolidation** can be set up based on the LPIS dataset to optimize on the long run the farmer´s ownership structure; also virtual land-consolidation is a possibility to optimize the future of smallholders.
- **Trust centers** will be a possibility to work further with the data for traceability solutions.

Villach, Austria in March 2012