

Global Case Writing Competition 2010

Corporate Sustainability Track

Finalist

Farmstar Goes Global: Corporate Entrepreneurship Bringing Sustainable Value Innovation to Agribusiness

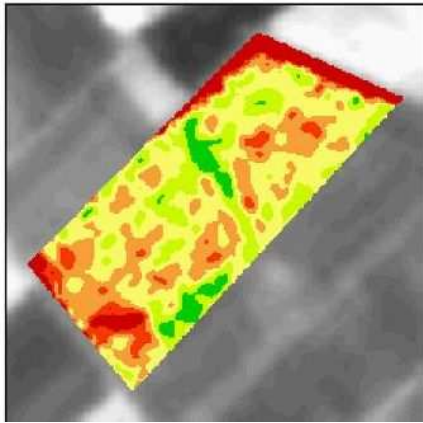
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“Man must rise above the Earth – to the top of the atmosphere and beyond – for only thus will he fully understand the world in which he lives.”

Socrates, 500 B.C.

In 2006, Infoterra France was created as a subsidiary of European aerospace group EADS-Astrium, to develop and commercialise Earth observation satellite technologies in partnership with Arvalis. Among these was a precision agriculture technology – Farmstar – which provided farmers with recommendations throughout the growing

season, and enabled subscribers to manage their crops with unprecedented precision. Research began in 1996 and by 2009 30 agricultural cooperatives in France representing almost 9,000 farmers and some 400,000 hectares of land had adopted the service. By 2008, Infoterra-Arvalis had a near monopoly on the rapidly growing market in France. This joint-venture had succeeded where many other companies had failed. The technology's potential was enormous but could they now protect their leading position in the French market and successfully transfer the knowledge to develop new markets abroad?

Agriculture and Earth Observation Systems

The Environmental Food Crisis

The global human population increases by more than 250,000 individuals per day. By 2050 there will be approximately 9.3 billion people on Earth.¹ Food production must therefore increase to meet their needs. However, there is pressure to use land for other purposes than growing food, such as biomass for low-carbon liquid bio-fuels as an alternative to conventional fossil fuels.

Agro-industries have two options to meet these demands: the extension of land under cultivation or intensification of existing systems. Extension has limited scope, particularly in regions with high population density such as South East Asia and East Africa. Even in Latin America and Sub-Saharan Africa, two regions where large areas of land could be brought under the plough, this would not occur without creating problems. The implications of agricultural extension are hotly debated: land is a multifunctional resource. In areas where land is both suitable and available, the protection of fragile local ecosystems is often a priority due to the vital role they play in maintaining the stability of the global climate and hydrological and nutrient cycles, as well as species diversity. Elsewhere, competing pressures for land use limits further extension. For example, over a quarter of the available land in Europe is negatively impacted by urbanisation. In China, rapid urbanisation is leading to the loss of vast swathes of productive land that cannot be replaced.

The alternative is to intensify existing systems via the mechanisation of agricultural production and the widespread use of fertilisers, pesticides and herbicides, collectively

¹ The current population is 6.8 billion (US Census Bureau.) Various forecasts of global population exist and vary according to assumptions about the speed at which fertility rates decline, the level at which global population stagnates, or the effect of catastrophic climate change and associated societal collapse.

referred to here as “inputs”. While this is feasible in many existing agricultural settings, with increased mechanisation the level of inputs to the agricultural system rises, as does the need for improved management of costs.

If inputs exceed requirements, it raises the risk of potential damage to both the field/farm (on-site) and to surrounding water resources and land (off-site). To illustrate, the Punjab, which is generally considered to be the birthplace of the ‘Green Revolution’ in the 1980s, now suffers from severe water pollution as a result of intensified farming that has in turn led to health problems among the local population. The catastrophe shows how inadequate control of the intensification process can end in disaster. Ever-increasing applications of fertiliser, herbicides and pesticides left the soil less fertile and more fragile, creating a vicious spiral in which costs rose while yields fell, and the ecosystem was damaged irreversibly.

Worldwide, examples of pristine wetlands and rivers damaged by nutrient contamination abound. As a result, the agricultural sector faces increasingly stringent regulation and control to minimise the negative impacts of agricultural activity on the environment. Agri-businesses are under pressure to ensure that extension is planned in a holistic and sustainable manner. Intensification has to be accompanied by progress in management systems to maximise the productivity of costly inputs and to minimise the potential for environmental degradation and associated risks. Efficient methods of managing agricultural systems with precision are needed (Exhibits1-3).

Precision Agriculture

Farmers everywhere face the daily challenge of managing crops with needs that vary from plant to plant, from field to field, across entire farms and farming regions. Crop yields vary for a multitude of reasons, the most significant being climatic and spatial (landscape/soils) variability.² Advanced crop management techniques attempt to take into account the spatial variability of the natural environment. The techniques that attempt to identify and quantify variation across the farm and use this to tailor farming practices according to plant needs are referred to as site specific crop management (SSCM) or precision agriculture (PA).

Precision agriculture is, however, not new. Traditional agricultural management systems evolved to take advantage of local variations in the productivity of the land. Some areas of the farm were highly productive, others less so. Farmers who knew their properties well designed the layout of fields accordingly, enclosing soils and terrains into parcels (fields) of similar slope, texture and drainage, and planting appropriate crops. The system was ‘human-scaled’ and variability could be managed.

Modern intensive farming is quite different. Mechanisation and pest control have enabled large expanses of land to be brought together under uniform management practices. On most modern farms, boundaries have been removed, making way for mono-cultures. Many small farms have merged into large agro-industrial complexes. But the underlying environmental conditions remain unchanged – variable in space and time. As the average farm size has increased dramatically, farmers are challenged to gather – and act upon – the information they need to manage with adequate precision.

² In June 2006, EADS Astrium, EADS Space Transportation and EADS Space Services were merged into a single company. Initially known as EADS SPACE, the subsidiary is now called EADS Astrium.

In the past, the additional effort required for larger producers to vary inputs precisely within individual fields according to crop needs was uneconomical. More recently, the cost of inputs (fertiliser, pesticide, herbicide, and diesel) has increased dramatically, intensifying the need to manage inputs more effectively. At the same time, environmental regulations have been strengthened. Together with cost increases, the search for ever-greater productivity and concern over environmental impacts have stimulated the development of precision agriculture methods. In modern PA systems, detailed information about the crop and/or soil is collected regularly and the results are analysed to show the spatial variation in crop growth and soil conditions. This information is used to modify interventions such as fertiliser, pesticide, herbicide and irrigation inputs, according to the individual plants' and soil requirements, techniques collectively known as variable rate application (VRA).

VRA techniques have proved successful in ensuring that inputs are applied only where needed, thereby reducing direct costs. They have also been effective in increasing yields. However, VRA technology has not been widely adopted by farmers due to the high cost of the information and the machinery required to make best use of it. As a result, only the most profitable businesses such as major agro-industrial complexes, or those with high value crops such as vineyards, have been in a position to take advantage of hi-tech VRA methods. Clearly, what was required to change this was a low cost source of information (Exhibits 4 & 5).

Commercialising Global Earth Observation Systems

In the early 1990s, global Earth observation systems were heralded as the "angel" technology that would allow farmers to intensify existing agricultural systems to improve yields efficiently and manage land sustainably. Earth observation systems are comprised of satellites³ receiving and processing infrastructures that convert the sensors' measurements into data. They represent the culmination of decades of technological progress in remote sensing (RS) technologies, which measure physical properties from a distance using electromagnetic energy. The most widely used RS device is the human eye. However, there are clear limitations to its ability and obvious advantages in being able to measure from perspectives and distances beyond those possible with the naked eye.

Remote sensing technologies were first developed and used for military purposes during World War II. The need for military reconnaissance led to the development and use of radar, sonar, thermal infra-red and multispectral scanners. Many of these systems were declassified in the 1960s, although the development of non-military remote sensing instruments did not really take off until NASA began methodological studies (aerial campaigns) using scanners carried by planes. In 1970, they were given the green light to build a satellite. Landsat-1 blasted off on 23rd July 1972 and was the first Earth-observing satellite to be launched with the sole purpose of monitoring the Earth's surface.

Extensive research programmes were carried out that showed how Landsat imagery could be used for the "public good". These included managing common property resources such as rivers and forests, and civil engineering projects such as the routing of roads and the planning of municipal land use, among others. This research also uncovered the potential for a commercial market to evolve, setting in motion a vociferous debate about the future of the system. Landsat users sought to increase access to inexpensive publicly accessible data,

³ Carrying sensors that measure various properties of the land surface.

whereas federal institutions made the case against privatising such critical information systems. In contrast, industry representatives pressed for privatisation as a means to strengthen the US position against potential international competition. The arguments continued for years until 1984, when Congress passed a bill permitting the development of privately owned satellite systems.⁴ The National Oceanic and Atmospheric Administration⁵ (NOAA) gave the first contract in 1985 to a private corporation, Earth Observation Satellite Company (EOSAT), to build, launch, operate and manage Landsat.

However, commercialisation proved to be problematic. Government policies designed to transfer the Landsat programme from public to private control were seriously flawed⁶ and market growth stagnated as operating costs remained high and new applications of the data were inhibited. By the time Landsat-5 was launched in 1984, the US had enjoyed monopoly status for 14 years. As a result, the NOAA was unable to prevent EOSAT from increasing image prices from \$650 to \$4,400, whilst the quality of the Landsat service deteriorated.

The US monopoly ended on 22nd February 1986, when the Centre National d'Etudes Spatiales (CNES), the French equivalent of NASA, launched Satellite Pour l'Observation de la Terre (SPOT). A privately owned company, SPOT Image, was created to deal with sales and distribution of SPOT imagery. As a result of this new player on the market, the price of Landsat imagery returned to competitive levels, at \$600 an image.

In 1989, the NOAA instructed EOSAT to turn the remaining Landsat satellites off. It was only after the intervention of the US president that the existing Landsat systems were left operational – a testament to its importance in service provision for public authorities. New legislation was drafted to protect the existing systems and encourage the development of new privately owned systems. In October 1992, the Land Remote Sensing Policy Act was signed into US law. This reversed the 1984 decision to commercialise the Landsat system, but more importantly allowed new private satellite systems to be built. It brought Landsat back into the hands of the government, citing the public benefits and the scientific, national security, and economic and social utility of remote sensing. The act also authorised the US Dept. of Commerce to license private-sector parties to build and operate commercial remote sensing systems.

The first phase of attempts at Landsat commercialisation ended in 1993 as the last EOSAT-owned and operated Landsat-6 tumbled to the ground when a vital system failed. Landsat-7, launched on 15th April 1999, was 100% government built. However, since the passing of the 1992 act, the door was open for the private sector to build and operate systems. From the early 1990s onwards, a series of private-sector ventures emerged aimed at designing, developing and operating medium and high resolution Earth observing satellites (Exhibit 6-7).

⁴ 1984 Land Remote Sensing Commercialisation Act

⁵ www.noaa.gov

⁶ L.W. Fritz (ISPRS), <http://www.isprs.org/publications/highlights/highlightso402/fritz.html>

The Origins of Farmstar – Phase 1

Merging, Research, Development & Demonstration (RD&D)

The race was on to design and build a new generation of high-resolution commercial satellites. Private companies on both sides of the Atlantic sought partners and rushed to propose new high-performance global satellite constellations. In the US, the main players, Boeing and McDonnell Douglas, held discussions regarding a potential merger and plans to develop a satellite constellation together. On the other side of the Atlantic, governments in Europe were concerned that the fragmented nature of the European aerospace industry would leave their domestic industries at a disadvantage when competing with the Americans. French, Spanish, British and German companies, Aérospatiale-Matra, Construcciones Aeronáuticas (CASA), British Aerospace and DaimlerChrysler Aerospace began a merger and rationalisation process that took four years and ultimately led to the creation of a single European Aeronautic Defence and Space Company (EADS N.V). This became EADS-Astrium⁷ in 2003, when it merged with Astrium, the civil and defence space systems service company.

The Farmstar story began seven years earlier in 1996 when GERC (Geographic and Environmental Research Corporation) approached the French-owned aerospace giant Aérospatiale-Matra⁸ – which would later form part of EADS – to collaborate on a series of airborne agricultural flight campaigns. GERC was among the first companies to propose the development of a privately built and owned constellation of low Earth-orbiting satellites (known as GEROS, the Geographical and Environmental Research Observation System) designed to collect land surface data worldwide. At the same time, Arvalis, the highly reputed para-statal (quasi-governmental) French agronomic research institute, was heavily involved with Matra Marconi Space in developing methods to retrieve useful crop information from remotely sensed data as part of the Xstar project.

The goal of these airborne campaigns was to develop algorithms for crop type identification, cover estimation, and to test the weed discrimination capabilities of the sensor. The number of acres under cultivation for each crop was important for national governments and major institutions interested in monitoring subsidy compliance or predicting future commodity prices. Farmers, on the other hand, knew what they grew, but were more interested in distinguishing crops from weeds. If weeds could be spotted early in the growing season before they spread herbicides, applications could be restricted to isolated patches. This would reduce costs, increase crop yields and avoid unnecessary environmental damage.

The flight campaigns provided some fruitful market information for Arvalis and EADS-Astrium. First, delivery of the product had to be timely, as the value to the farmer diminished rapidly with late delivery. Second, information was needed at various times during the crop growing period, so the product delivery must be repeatable – supported by frequent revisits to the site. Third, the product must be integrated with existing farm management systems such as geographical information systems. Finally, and perhaps most significantly, the information embodied in the product must be sensitive and consistent. This implied going

⁷ In June 2006, EADS Astrium, EADS Space Transportation and EADS Space Services were merged into a single company. Initially known as EADS SPACE, the subsidiary is now called EADS Astrium.

⁸ For simplicity we refer to Aérospatiale-Matra as EADS-Astrium in the remainder of the case.

beyond rough measures (indices) of crop development to provide information that was presented in a manner better suited to the farmers' needs.

The algorithms under development were critical in providing timely and appropriate information. But despite the enthusiasm of US scientists for the partnership, they were unable to share all their intellectual property (IP) with the French company. The reasons were twofold and related: the US government was the principal funding body of GERC and the intellectual property embodied in the algorithms was considered too valuable and sensitive. The EADS-Astrium team, frustrated by the lack of information-sharing and confident that they could develop algorithms of the same quality, ceased collaboration on the GEROS campaigns.

However, EADS-Astrium were ready to play the waiting game. Key members of the Astrium team, such as Jean-Michel Aubertin, had been "bitten by the bug". They were convinced of the future potential of agricultural service provision and were determined to see EADS-Astrium move forward with the project, albeit with new partners. As a result, in 1998 EADS-Astrium began campaigns in the American Midwest with help from US companies Novartis, Monsanto and Cargill.

At the same time, another US company, Resource21, also began discussions with the French team. They had ambitious plans to develop a medium resolution scanner as well as to build, launch and operate a constellation of satellites on which it would fly. Resource21, a Colorado-based company that had been created in 1995, was jointly owned by Boeing (63%), BAE Systems, Farmland Industries and the Institute for Technology Development. Its mission was:

"To build, launch and operate a constellation of satellites that would provide 1/18 acre spatial resolution (15m²) coverage of any given place on the earth every three days. The Farmview product would be processed at a central point and then delivered to the customer within 48 hours."

With their goals aligned, the two companies began work on a project that would last two years and involve the development of a business plan for a joint venture. The business plan was ambitious and considered by some observers to be over optimistic. It was, as the Deputy Head of Department at EADS-Astrium noted, "full of exponential growth forecasts, too good to be true".

Once more, the EADS-Astrium team faced disappointment. For a second time much of the technology Boeing brought to the table had its origins in US defence and was judged too confidential and sensitive to share with the French company. By 2002, continuing as unequal partners in a long-term venture was no longer an option. EADS-Astrium had no choice but to withdraw from the project. It seemed that collaboration with an American company on sensitive research, development and demonstration (RD&D) was just not a viable strategy.

Not surprisingly, EADS-Astrium had been working on a solution to this recurring problem. Back in France, Arvalis and EADS-Astrium had continued to work together to develop a home-grown solution. Arvalis was a "very" French organisation, as Arvalis researcher Francois Laurent noted:

"Arvalis doesn't receive money directly from the French government but 40% is paid for through a 'voluntary-obligatory' subscription and a tax levied on all farmers, 30% comes from a state run fund and 30% from brochures, reports and consulting."

From 1996 to 1998, Arvalis and EADS-Astrium worked together on the development of algorithms that enabled the extraction of information on plant physiology, similar to those the US researchers were unwilling to share. In 1998, with limited EU funding, they completed a first set of airborne pilot tests across the wheat-growing regions of France with great success. The principal breakthrough came as it became increasingly evident that the information retrieval algorithms would work with existing SPOT imagery. It was no longer imperative to finance the costly process of developing a privately-owned 'dedicated' satellite system – at least not yet.

As the collaboration with US-based Resource21 ended, the relationship between EADS-Astrium and Arvalis blossomed. Arvalis⁹ provided the agronomic expertise and plant growth models that Astrium needed to 'invert' the remotely sensed crop data and retrieve meaningful information. Combining bottom-up models with top-down observations permitted the Astrium team to retrieve information on the plant physiology. This was far more valuable to crop managers than crop status reports from indices, which could only provide indirect information. The algorithms developed by Astrium and Arvalis enabled them to provide quantitative information on the chlorophyll content and density of the leaves, which directly reflected the health and development status of the crop. With this information in hand, crop managers could identify the interventions that were necessary with far less ambiguity.

Product development began with wheat crops, followed a year later by rapeseed. Barley, corn and sugar beet joined the product portfolio through collaboration with the research institutes Cetiom and ITB, which provided expertise with regards to oilseed and sugar beet crops respectively. By 2002 they were ready to launch the first commercial service in France using the technology that would later be known as Farmstar (Exhibits 8 & 9).

Farmstar is Born – Phase 2

The Farmstar Process, Products and Organisational Structure

Farmers who subscribe to the Farmstar service, for an average cost of €10 per hectare, receive management advice for each of their plots at key stages of crop growth. The farmer provides supplementary details that are necessary for image processing and information retrieval such as crop variety, date of sowing, depth and type of soil, and type of irrigation system. These are used to make a plot database within a geographical information system (GIS). The three satellites in the SPOT constellation must be programmed to target specific plots on particular dates that coincide with important crop growth stages. Once the images are collected, SPOT Image validates them to ensure that cloud cover does not render them useless. Often it is necessary to use two or more images collected on successive days to ensure adequate cloud-free coverage. During the 2004 campaign, an average of 1.4 images had to be combined per period and per site to cover 99% of the target plots. The validated images are orthorectified¹⁰ and delivered to EADS-Astrium within two days. EADS-Astrium then applies

⁹ Later also Cetiom and ITB

¹⁰ Orthorectification is the process of correcting spatial distortions in the image caused by sensor movement and terrain (hills, mountains and valleys) so that images taken on different dates can be exactly overlaid within a Geographical Information System (GIS).

its algorithms using automated processing routines to create period specific crop status maps (Exhibit 10-11).

Within five days of signing up to the Farmstar service farmers are sent recommendations and/or yield maps to enable them to improve management of their crops instantly. Each plot map is accompanied by quantitative data that can be used directly. For winter wheat, the recommendation map for the third nitrogen application delivered in April/May enables farmers to determine the optimal dose according to the needs of the crop and to plan the timing of the interventions (for fertilising and spraying) by virtue of a forecast of the development stage of the crop.

"I grow wheat on 120 hectares and signed up to Farmstar services for two key reasons; because I was curious of this new innovative tool and because I wished to have a reliable tool to optimise the application of nitrogen fertiliser on my durum wheat crops. The results for 2006 are ambiguous, but it is my fault. I thought that the quantity of nitrogen fertiliser that Farmstar recommended seemed too little, in particular in comparison to what I usually apply and considering the yield that I wished to get. I doubted the information and I confess that I did not follow Farmstar's advice. In hindsight, when analysing my results I regret that I did not follow the advice because Farmstar could have saved me fertilisers and money. This year I will sign up again, for 25-30 hectares of durum wheat, and this time I am following the advice meticulously."

Michel Duprat, farmer, La Beche, near L'Isle Jourdain.¹¹

Over the initial 2002 to 2006 commercialisation phase, the Farmstar product generated significant economic and environmental benefits, including:

- *Time saving* as remote management of crops made it possible to target problematic areas early in the growing period, reducing the need for sample collection and analysis and subsequent costly late interventions.
- *Increased profitability* as savings of costly nitrogen and plant hormone inputs (regulators to reduce the risk of lodging) were realised, covering the cost of the service (€10/ha).
- *Increased yield and quality* of managed (versus unmanaged) plots was estimated to contribute to between €25 and €35/ha to the gross margin.
- *Reduced environmental impacts* as potentially harmful inputs were reduced to a minimum.

The information provided was specific to each crop and presented in a format that the farmers were familiar with. This familiarity was further enhanced by a network of distributors and support. Farmstar was more than just a map, it was a product-service system. Recognising this fact was key to its future success (Exhibit 12).

¹¹ Quotes are translated from French and were first published in the Farmstar press dossier presented at a press conference in Toulouse, 13 December 2006.

The Creation of Infoterra - Phase 3

Accelerated Commercialisation

Infoterra France was set up in January 2006 as a wholly-owned subsidiary of EADS-Astrium.¹² It was a result of the merger of the EADS subsidiary ISTAR and teams from the Earth Observation and Services division of EADS-Astrium. It had offices in France, the UK, Spain and Germany. The subsidiary was created to focus on Earth observation services, environmental protection, risk management and information services for all forms of land use, notably agriculture. The implication of this for Farmstar was clear – they now had a formal group that was responsible for marketing and extending the service. Until this time, R&D for Farmstar had been funded equally by Infoterra's parent company, EADS-Astrium, and the agronomic research institute Arvalis. At this stage, the service had yet to break even financially. The mission for now was to make the product-service profitable. While the validation phase had been successfully completed, the full potential of commercialising the product had still to be achieved.

Distribution, Marketing and Partnerships

For distribution and marketing, the Farmstar service depended on an extended network of actors in a unique way. Farmers took out a subscription to Farmstar for the plots they wanted to manage through their agricultural cooperative – they did not subscribe individually. France has a tradition of farming cooperatives that dates back to the 17th century with the creation of the first dairy cooperative. These organisations were created by farmers to “organise collectively and in solidarity the sourcing and the marketing of their production”.¹³ In 2008 total revenues were over €80 billion, with nine out of ten farmer's belonging to a cooperative.¹⁴ Their power and influence in the industry is undeniable.

Involvement of the agronomic research community, specifically Arvalis, brought Farmstar to the attention of the agricultural cooperatives. The collaborative R&D and first-stage validation/commercialisation process that had linked Infoterra to Arvalis resulted in the creation of an extended network of stakeholders with a common goal – increased agricultural productivity at a lower economic and environmental cost. The importance of fostering strong links to the agricultural cooperatives did not go unnoticed. Arvalis knew the value of the operational relationships they had developed with farmers and agricultural cooperatives, and understood that their para-statal status created a degree of trust necessary for the new technology to be accepted that no private company could copy. As a partner of Arvalis, Infoterra could benefit from this existing relationship. With considerable foresight, Arvalis encouraged Infoterra to use this network as the basis for its marketing and distribution. As a result the marketing and distribution strategy of Infoterra-Arvalis focused firmly on the cooperatives rather than individual farmers.

“It was a more effective ‘to consumer’ sales communication through a co-located and motivating intermediary. The cooperative representatives are close enough to visit and answer questions and explain information. There is also a significant extension

¹² Infoterra GmbH in Germany and Infoterra Ltd in the UK had already been established in 2002.

¹³ COOP de France, www.coopdefrance.coop (source CFCA).

¹⁴ Equal to 304,000 individual farms.

of low cost R&D as cooperatives maintain a role of technical guidance and support which generates information for us on how to improve the service.”

Jean-Paul Bordes, Arvalis

One unexpected spin-off of the targeted introduction of the cooperatives into the supply side value chain was the collaborative vertical integration that emerged. Farmstar encouraged a sense of “community” within cooperatives by bringing together farmers for meetings and workshops. It led to more focused, precise and in-depth discussion between farmers facing similar problems. Furthermore it brought the research and industry communities together. Farmstar united technicians, farmers and cooperatives. The cooperatives used Farmstar in a similar way as they would a drive for ISO certification – it helped pull diverse individuals together to strive for a common goal. As one director of a cooperative put it, “Farmstar has brought the farmers closer to their land and scientists closer to their science.”

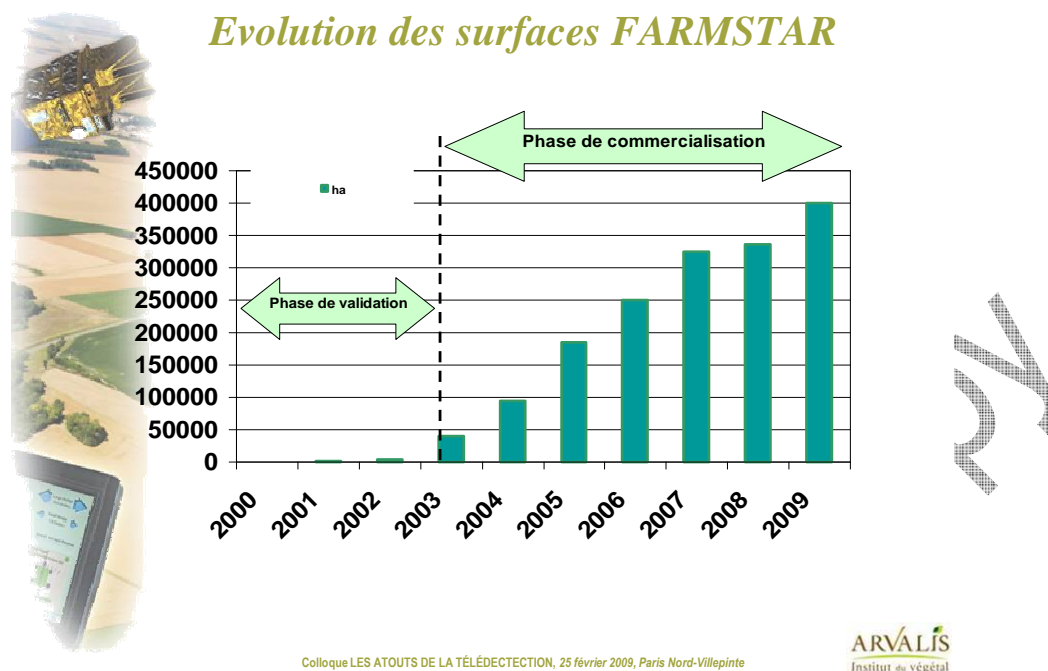
As the potential benefits of Farmstar became clearer to the agricultural cooperatives and regional Chambers of Agriculture, word-of-mouth publicity spread quickly, with dramatic implications for marketing and the expansion of their client base.

“Aware of Farmstar’s potential, the Terre de Gascogne farmers’ cooperative invested in the development of Farmstar across the region in 2006: 42 farmers – cultivating more than 7,000 hectares of land, signed up to Farmstar’s services. The users regularly attended technical information meetings that the Terre de Gascogne Farmers’ co-operative organised. These meetings allowed members to discuss the advice that they had gotten through Farmstar’s map information and to put the appropriate crop interventions in place. The Farmstar campaign results indicated a clear economic interest in using Farmstar, in particular in optimising the application of inputs and increasing yield and crop quality. The end of campaign assessment clearly showed Farmstar’s advantages. When growing oilseed rape, Farmstar information saved 40-70 units of nitrogen in comparison to traditional methods, while still optimising yield. For bread wheat, (assessment on Galibier wheat variant) Farmstar information helped save 12€/hectare of plant hormone applications and optimize the amount of nitrogen fertiliser used. The information also helped increase the total yield by 2 quintals/hectare. The positive results encouraged us to continue with Farmstar in 2007.”

Jean-Francois Colomes, Terre de Gascogne, Gers region

The strategy bore fruit. Despite minimal efforts on the side of Infoterra to reach individual farmers, the client base continued to grow in France. (Figure 1 shows the growth of Farmstar subscription rates over the period 2000 to 2009). By 2008 the service covered 337,000 hectares of wheat, barley and oilseed rape, a total of 33,000 individual fields belonging to 7,400 farmers, who were members of 28 cooperatives throughout France.

The cooperatives were able to recommend Farmstar on the basis of their own independent validation process. Without Infoterra-Arvalis’s knowledge they carried out sporadic tests to ensure that the service was financially worthwhile for their members. In 2008 these farmers estimated a return of between €20 and €60 per hectare. In nearly all cases, the costs of the service were covered by either yield or quality improvements or input reductions.

Figure 1. Evolution of Farmstar Subscription Rates

Source: Infoterra-Arvalis

In 2008, EADS-Astrium acquired a majority stake in SPOT Image in a move that they hoped would “propel the company to the forefront of the international space imagery market”.¹⁵ This gave the French company an 81% stake in the Toulouse-based optical imaging specialist. Other shareholders included the Swedish Space Corporation (SSC), the French telecoms company Alcatel Group, the Institut Géographique National (IGN) and the government of Belgium, while the CNES retained a small “golden” share. The company integrated SPOT Image into the Earth Observation division of Astrium Services alongside Infoterra.

“By gaining control of Spot Image, EADS is now in a position to develop an integrated strategy for the full range of Earth observation services and applications along the entire geo-information value chain.”¹⁶

Eric Beranger, CEO, EADS.

The move in this direction reflected EADS-Astrium’s long-term strategy and commitment to the development of satellite-based services through its subsidiary Infoterra, as part of a vertically-integrated industry-spanning image supply, service development and provision. Involvement in SPOT Image represented a low-risk option for reliable image supply using existing satellite systems given the often uncertain processes involved in satellite system design, construction and launch.

¹⁵ “Astrium Takes Control of Spot Image” Michael Taverna. Aviation Week. 15 January 2008.

¹⁶ *Ibid.*

Farmstar Goes Global!

Despite the undoubted success of the Farmstar programme in France, its success abroad was less sure-footed. While the programme was being successfully developed in France, trials across the channel in the UK were experiencing problems.

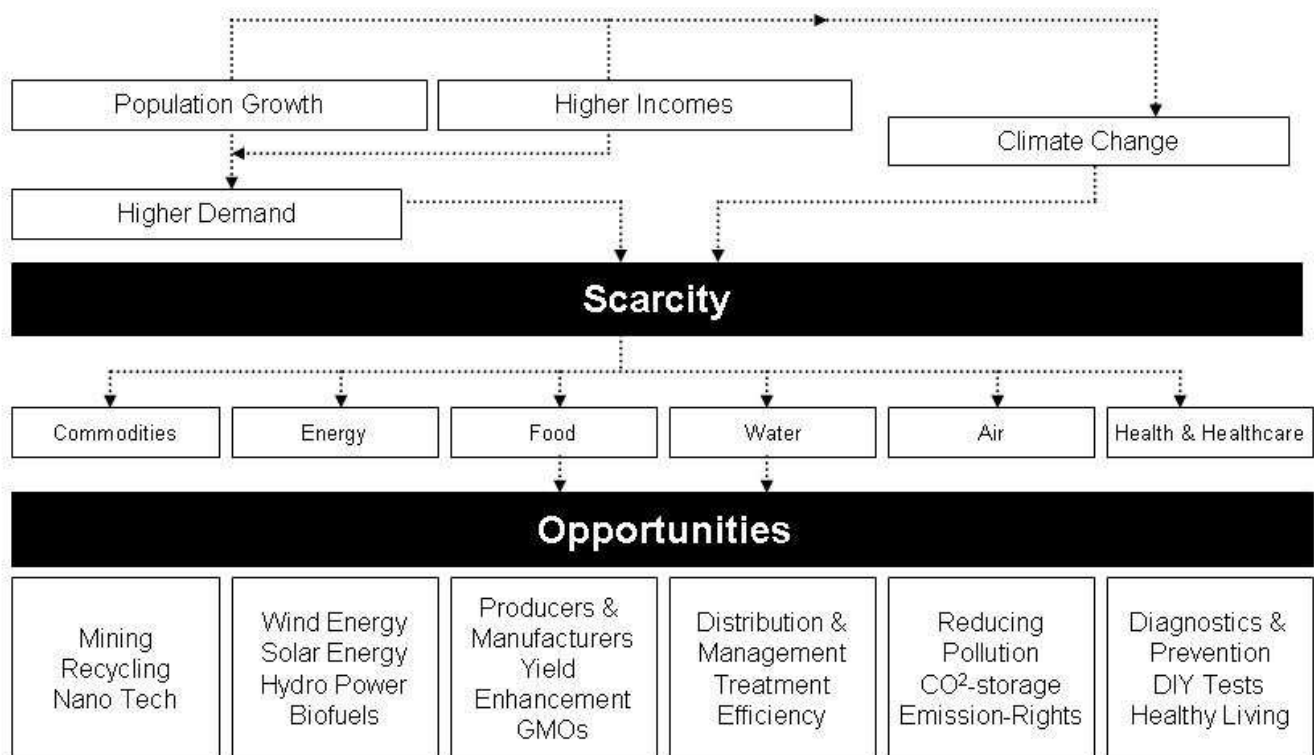
The UK farming industry differs to that of the French. Firstly, the cooperatives that played such a key role in the marketing of the service in France are fewer and function very differently in the UK. Lacking this organisational layer between service provider and service user, providing guidance, support and advice, bringing farmers together to discuss and experiment in unison, as well as serving as a marketing tool communicating the benefits of the service, adoption rates stalled. Second, while farmers are generally renowned for their robust attitude to external influences, British farmers are particularly independent, extremely risk-averse and generally suspicious of the productivity benefits touted by 'new fangled' technologies. This cultural difference was exacerbated by the lack of existing Arvalis-cooperative relationships and the "community" influence of the cooperatives. Third, the Farmstar product had been developed in France, primarily for French wheat and rape growers. It was actually ill-suited to the farming practices and the fertilisation recommendation process commonly used in the UK. A final reason for the failure in the UK was the climate. Despite being geographically quite close to France, the UK is more often shrouded in cloud, make clear images impossible.

In 2009 the Farmstar programme was finally breaking even due to its huge success in France. Now the company needed to address how it could expand beyond these national boundaries and avoid a repeat of the UK failure. In late 2008, Infoterra began marketing new services (CropForecaster) in the US and Brazil. Another venture was also underway in the Ukraine, the so-called 'breadbasket of Europe'. Could Farmstar enjoy the same success in these countries? How would they have to adapt their offering to make the service truly global, or would they have to take it on a country-to-country basis?

With new players coming into the market, how would Farmstar face the competition? The Farmstar service was one of very few to have been successfully commercialised. Resource 21, its American counterpart, had disappeared in 2003 when it failed to win the US government's Landsat mission deal. Other teams, such as the Rhone Poulenc' Crowseye, TRW Lewis and GEROS, had also come and gone. In February 2009, a new German company, RapidEye, announced it was ready for business as: "the only geospatial solutions provider to own and operate their own satellite constellation". Was this new German outfit a threat to the French companies or just one of many new rivals that would enter the game? If so, how could Infoterra and Arvalis keep ahead of these new competitors and remain the market leaders?

Exhibit 1: The Environmental Food Crisis: Drivers of Change

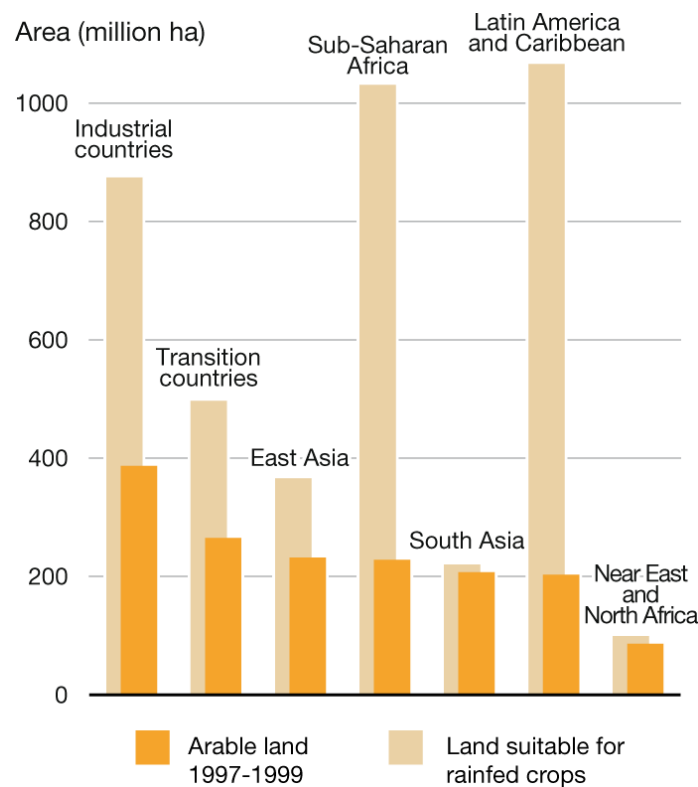
The IRIS Model of the New Scarcities



Source: IRIS Research (2007): Scarcity in Abundance: Investing in New Scarcities.

Exhibit 2: The Environmental Food Crisis: Opportunities to Extend?

Current projections suggest that an additional 120 million hectares – an area twice the size of France or one-third that of India – will be needed to support expected growth in food production by 2030, mainly in developing countries (FAO, 2003), without considering the compensation required for certain losses of productive land.

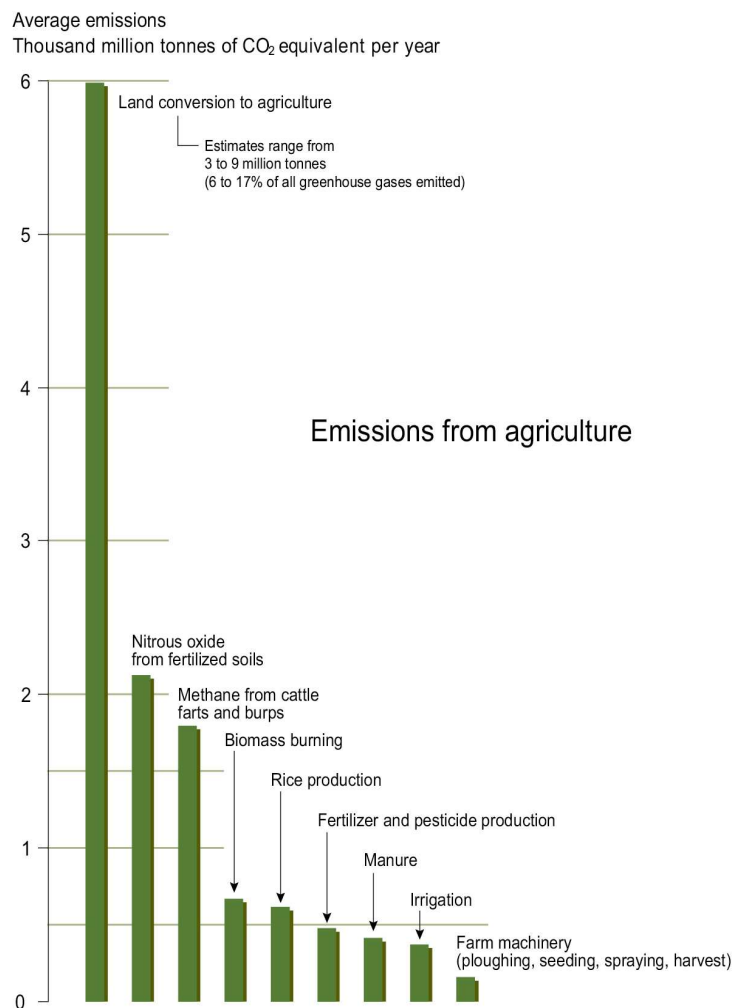


Source: FAO 2003, Cartographer: Hugo Ahlenius, Nordpil

The demand for irrigated land is projected to increase by 56% in Sub-Saharan Africa (from 4.5 to 7 million ha), and rainfed land by 40% (from 150 to 210 million ha), without considering ecosystem services losses and setbacks in yields and available cropland. Increases in available cropland may be possible in Latin America through the conversion of rainforests, but this will only accelerate climate change and biodiversity losses, causing feedback loops that may hinder the projected increases in crop yields. The potential for increases is also questionable in large parts of Sub-Saharan Africa due to political, socio-economic and environmental constraints. In Asia, nearly 95% of the potential cropland has already been used (FAO 2006, FAO 2003). Even if such increases are not restricted by other land use and the protection of tropical rainforests, changes in the proportion of non-food crops (such as biofuels) to food crops may have even greater impacts on the available cropland for food production (UNEP 2009).

Exhibit 3: The Environmental Food Crisis: Impacts of Extension and Intensification

The extension of agricultural activities to uncultivated land generates significant greenhouse gases. As vegetation is removed and soils are disturbed, carbon is released from vegetation and soil sinks. Land conversion from natural ecosystems to agriculture contributes between 6% and 17% of all greenhouse gases emitted in a year.



Source: Greenpeace, Cool farming: Climate impacts of agriculture and mitigation potential, January 2008 (data for 2005): Cartographer: UNEP/GRID-Arendal.

Not only is there a one-off release of greenhouse gases, but subsequent farming activity further contributes to total additional greenhouse gas emissions. For example, the application of nitrogen fertilisers releases a further 2.5 thousand million tonnes of CO₂ equivalent per annum in the form of nitrous oxide, a greenhouse gas some 296 times more damaging than an equivalent amount of CO₂.

Exhibit 4: The Concept and Process of Precision Agriculture

Precision agriculture¹⁷ represents a suite of management practices developed to cope with the spatial variability of the environment. It's about doing the right thing, in the right place, in the right way, at the right time. Critical components of precision agriculture systems are:

- A. Spatial referencing via GPS
- B. Crop, Soil and Climate Monitoring
- C. Attribute Mapping
- D. Decision Support Systems
- E. Differential Action



Collected information may be used to more precisely evaluate optimum sowing density, estimate fertilizer and other inputs needs, and to more accurately predict crop yields. It seeks to avoid applying inflexible practices to a crop, regardless of local soil/climate conditions, and may help to better assess local situations of disease or lodging (when a stalk falls over in the wind and rots on the ground.) The latter may occur as a result of an excess of applied nitrogen fertiliser weakening the plant stem.

¹⁷ Precision agriculture has been defined as 'Observation, impact assessment and timely strategic response to fine-scale variation in causative components of an agricultural production process.'

Exhibit 5: The Promise and Pitfalls of Precision Agriculture¹⁸

The promise:

1. Save money

Soil loosening only where necessary

Apply P & K only where deficient or matching replacement with offtake

Apply herbicides only where the weeds grow

Apply growth regulator only where required

2. Greater efficiency

Match seed rate to soil conditions for optimum plant population

Cultivate faster where soil is well structured

3. Better husbandry

Identify areas of poor yield for special attention or set-aside

Evaluate the effect of husbandry decisions

Use yield maps to identify areas particularly suitable for different crops

4. Environmental benefits

Reduced pesticide usage

Highly targeted application of pesticides and fertilisers

Avoid over-cultivation of soil.

With such potential to increase profits, why doesn't everyone do it?

The pitfalls

1. Too big, too complicated, too expensive

Precision agriculture works best when integrated into the entire farming process involving a combination of sensors to collect information and machinery that is able to act upon the gathered information such as variable rate applicators. Farmers have largely been unaware that they could adopt the system in stages to considerable benefit.

2. High costs of data collection

The historical problem for PA has been obtaining adequate information without incurring too much additional expense. Clearly satellite sensor systems address this

¹⁸ Adapted from Cragg, A. The promise, pitfalls and practicalities of precision farming. HGCA Conference 2004: Managing soil and roots for profitable production.

issue, but ancillary data (on soils for example) is necessary to make use of the remotely sensed data and this is still expensive.

3. Interpretation is required

Providing information in the form of maps is simply not good enough. The maps need interpreting to provide clear guidelines and this can cost more money than the map itself.

4. Inability to evaluate the benefit

This is perhaps the most common criticism of PA. It can be extremely hard to attribute yield improvements exclusively to PA activities. This is exacerbated by year to year variations in weather, in disease and pest attacks.

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Exhibit 6: Important Characteristics of Remote Sensing and Global Earth Observation Systems

Spatial scale-resolution-coverage

Remote sensing images are composed of a matrix of *pixels*, which are the smallest units of an image. Image pixels are square and represent a certain area on an image. It is important to distinguish between pixel size and spatial resolution - they are not interchangeable. The detail discernible in an image is dependent on the *spatial resolution* of the sensor and refers to the size of the smallest possible feature that can be detected. Images where only large features are visible are said to have *coarse or low resolution*. In *fine or high resolution* images, small objects can be detected. Images can be displayed with pixels larger than the original spatial resolution.

The ratio of distance on an image or map to actual ground distance is referred to as *scale*. If you had a map with a scale of 1:100,000, an object of 1cm length on the map would actually be an object 100,000cm (1km) long on the ground. Maps or images with small "map-to-ground ratios" are referred to as small scale (e.g. 1:100,000), and those with larger ratios (e.g. 1:5,000) are called large scale.

The distance between the target being imaged and the platform plays a large role in determining the detail of information obtained and the total area imaged by the sensor. Sensors on onboard platforms far away from their targets typically view a larger area but provide less detail. The size of the imaged area and the repeatability of the fly-over on a single date determine the *coverage* of the system.

Spectral resolution and coverage

Remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions. *Spectral resolution* describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band and the greater the ability to isolate individual components of the signal. A high spectral resolution facilitates fine discrimination between different targets based on the spectral response in each of the narrow bands.

Spectral coverage refers to the range of the electromagnetic spectrum across which measurements are made. *Panchromatic* sensors collect data in the red, blue and green visible wavelengths. *Multispectral* scanners collect data in several (4-14) contiguous wavelengths spanning the visible, near infra-red and ultraviolet. *Hyperspectral* scanners make up to 256 contiguous measurements across the same range but with greater spectral resolution.

Mixed signals

The signal (reflected sunlight) from the land surface viewed from space, imaged by the sensor and represented by a pixel is typically a mixture of reflected energy from plants and soil. To obtain useful information about either it is necessary to isolate the signal from the plant by removing the influence from the soil. Elaborate algorithms have been developed to perform this process rapidly.

Exhibit 7: Successes and Failures of the Commercialisation Process

By the end of the 1990s many companies and 'parapublic' institutions had ambitious plans to design, build, launch and operate privately owned global Earth observation satellite systems. The table below lists these, and indicates those which have resulted in a successful launch and an operating system. Less than one project in three has been completed. Several failed to get off the drawing board, others failed during the launch and release process. For EADS-Astrium, security of image supply and guaranteed quality of service from SPOT systems were clearly of importance in the decision not to build a dedicated system in the 1990s, and to continue to work with SPOT.

Commercial satellite launches scheduled for 1998-01

		Planned launch date	Resolution	Bands	Operational
Earth Watch (USA)					
EarlyBird**		1997	15m	3	failed
QuickBird 1***		1999	4.5m	4	failed
QuickBird 2		2000	4.5 m	4	YES (2001)
Geo-Eye (USA, formerly Orbimage)					
Orbview-3		1999	4 m	4	YES (2003)
Orbview-4		2000	4 m	4	failed
Space Imaging					
IKONOS 1		1998	4 m	4	failed
IKONOS 2		1999	4 m	4	YES (1999)
IKONOS 3		2002	4 m	4	cancelled
CNES (France)					
SPOT 4		1998	20 m	4	YES (1998)
SPOT 5		2001	10 m	?	YES (2002)
Other					
TRW Lewis* (USA)		1997	30 m	256	failed
GDE Systems (USA)		2000	?m	?	Cancelled
Resource21 (USA, Canada)		2000	10 m	3	Cancelled
GERS (USA)		1998	10m	4	Cancelled

* Lewis was launched but lost when thruster rockets failed to place the satellite in its proper orbit. It was funded by government but has strong commercial interests.

** EarlyBird was launched 12/24/97. Communications were lost shortly after orbit.

*** Quickbird 1 was lost on launch.

Current commercial mid to high-resolution systems as of May 2009

Landsat 7

SPOT 5

Ikonos 3

GeoEye-1 : now the world's best commercial satellite.

Inspection Copy

Exhibit 8: The Players

EADS is a global leader in aerospace and related services. In 2007 EADS generated revenues of €39.1 billion and employed a workforce of approximately 116,000. The group includes the world's largest helicopter supplier, Eurocopter, and EADS Astrium, the European leader in space programmes from Ariane to Galileo. Its Defence and Security Division is a provider of comprehensive systems solutions and makes EADS the major partner in the Eurofighter consortium as well as a stakeholder in the missile provider MBDA. EADS also develops the A400M through its Military Transport Aircraft Division.

Source:

Astrium is a wholly owned subsidiary dedicated to providing civil and defence space systems and services. In 2007 Astrium had a turnover of €3.5 billion with 12,000 employees in France, Germany, the UK, Spain and the Netherlands. Its three main areas of activity are Astrium Space Transportation for launchers and orbital infrastructure; Astrium Satellites for spacecraft and ground segment; and finally its wholly owned Astrium Services for the development and delivery of satellite services.

Source:

Astrium Services is a wholly owned subsidiary of Astrium, offering a unique 'one-stop-shop' in satellite services, with unrivalled capability and expertise in secure communications, Earth observation services and navigation services. It is the European provider of miltatcom services, including the pioneering Skynet 5 service, and a world-leading supplier of geo-information products and services. Astrium Services meets its customer requirements with innovative and highly competitive end-to-end solutions.

Source:

Infoterra Group – Wholly owned by Astrium, the group is a leading provider of geo-information products and services for managing the development, environment and security of the changing world. It has companies in France, Germany, Spain, the UK and Hungary. Its global customers include international companies, national, regional and local governments/authorities throughout Europe as well as organisations including the European Commission and the European Space Agency.

Source: www.spotimage.fr

ARVALIS

Arvalis is at the interface between the basic research and the extension. Its mission is to provide useful, usable and used information, techniques and services to farmers, agricultural organizations and firms from the various sectors, for them to adapt their production to the market changes using environment-friendly cropping systems. Arvalis is a farmers' organization, and the composition of its board of directors reflects this: representatives of union of farmers, co-operatives and other organizations. Arvalis' president, Christophe Terrain, is a farmer himself, in the South of France.

Source: www.arvalisinstitutduvegetal.fr

Exhibit 9: Farmstar Information Flows

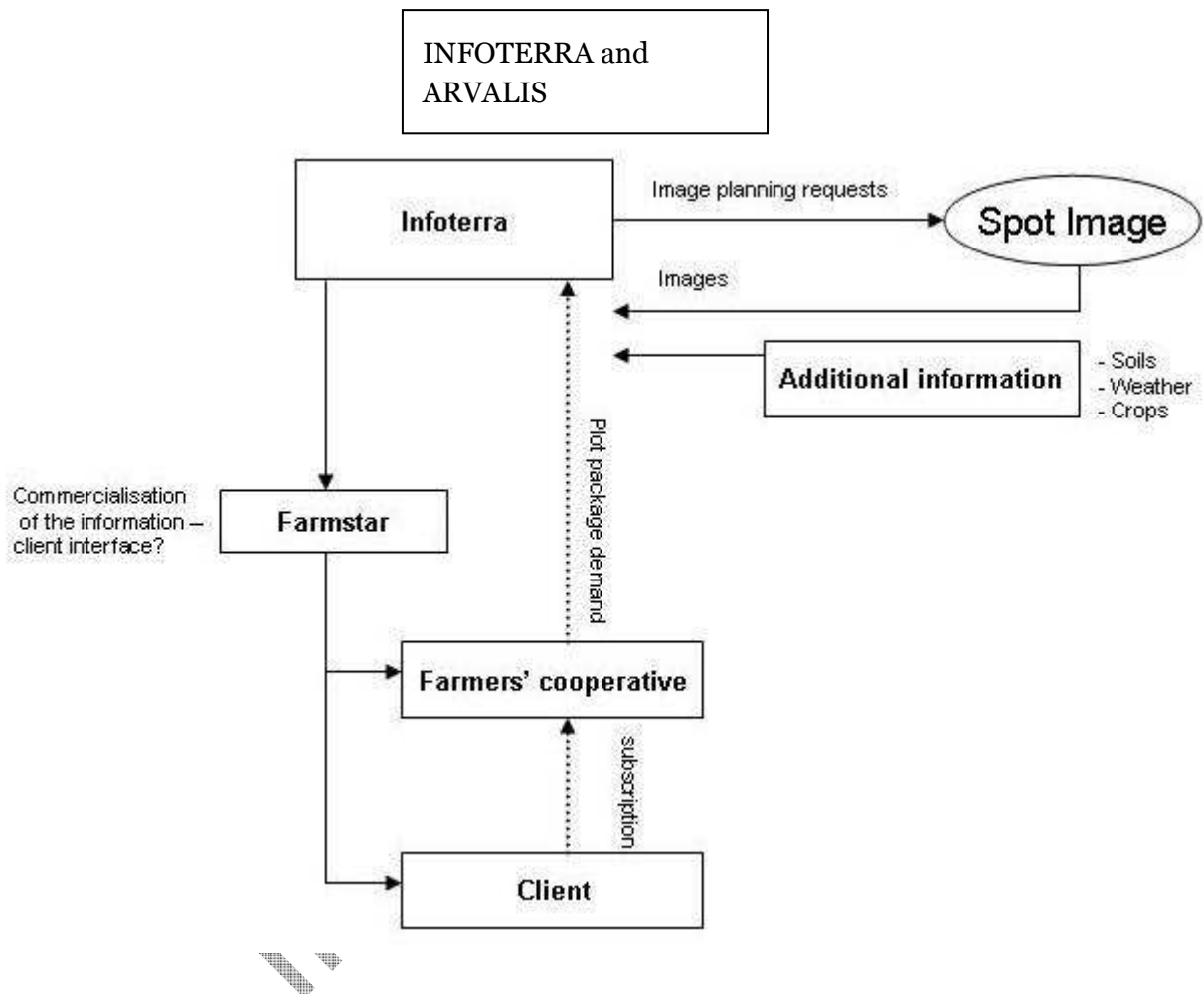
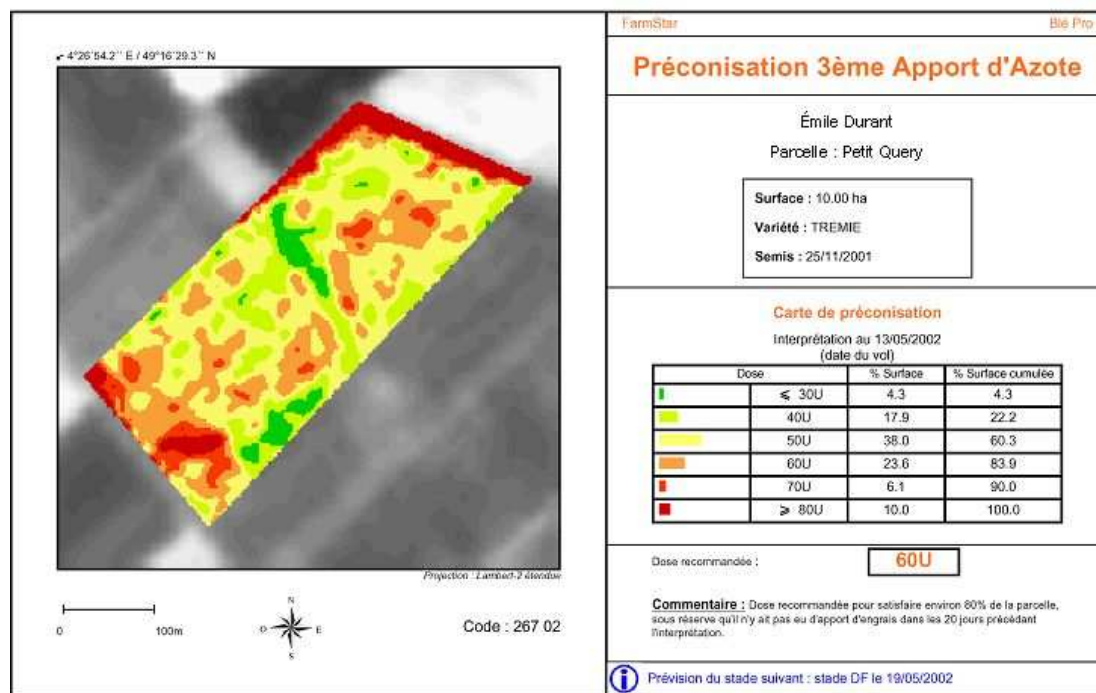
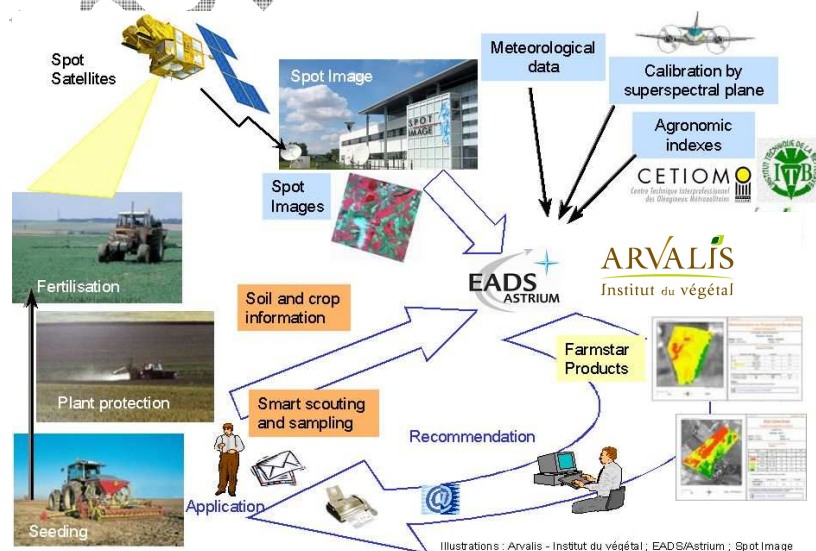


Exhibit 10: Farmstar: Crop Management with Spot

At precise times during the growing season farmers receive a detailed image of each field for which they have a subscription. Below is a recommendation for the third application of nitrogen-based fertiliser for a field of 10ha, indicating that 38% of the field would benefit from 50 units of fertiliser, 23.6% 60 units, and so on. The image reveals that requirements are greatest towards the field boundary. This spatial information can prove invaluable in determining underlying causes.



The Sequence of a Farmstar campaign



Illustrations: Arvalis – Institut du vegetal, EADS-Astrium, SpotImage.

Advice to farmers is provided at key dates in the growing season. This requires ancillary data provision, processing, transformation from data to information and delivery.

Exhibit 11: Calendar of Farmstar Products for Winter Wheat

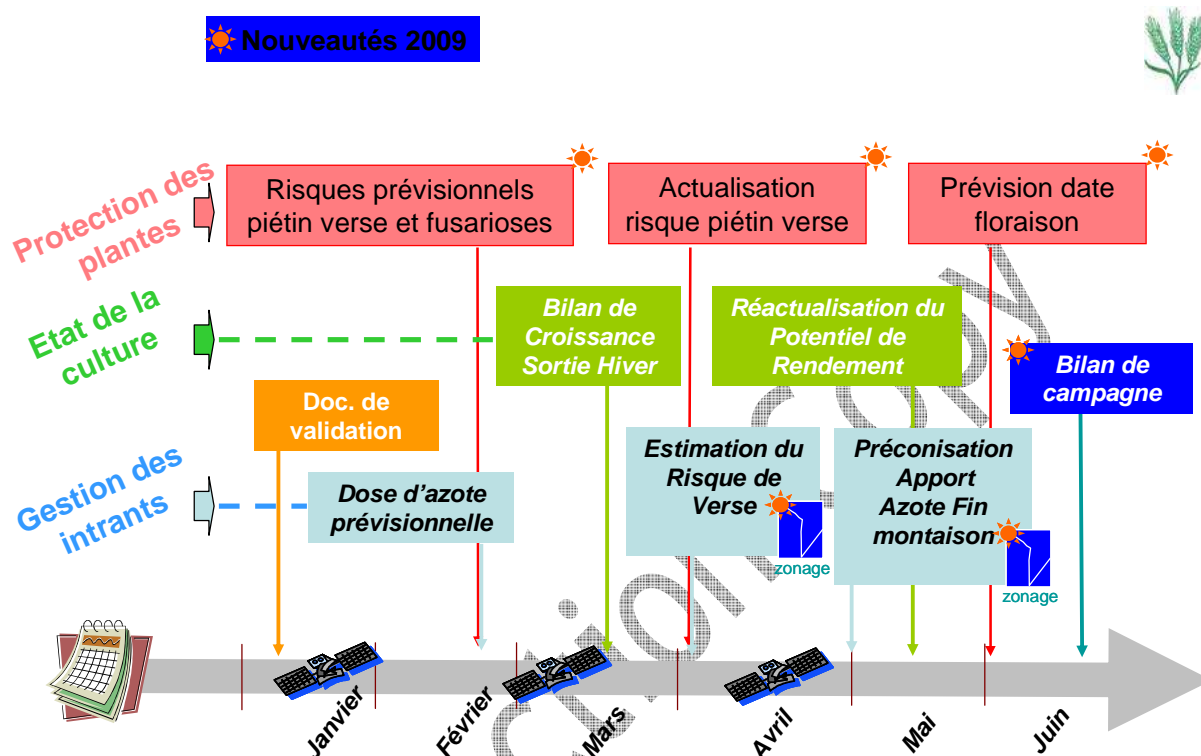


Illustration: Arvalis – Institut du végétal, EADS-Astrium, SpotImage.

The fact that the **heterogeneity of plots** is taken into account provides information for all points in a field and enables optimum application of inputs for homogeneous zones.

Time saving: remote management of crops makes it possible to target areas for scouting at problematic places and to reduce the need for taking samples.

Increase in profitability: savings in inputs are possible for nitrogen and regulators (risk of lodging). Savings are not systematic but whenever possible, they cover the price of the service which is approximately **10 €/ha** for wheat.

Increase in yield and quality (protein content for wheat, oil content for rapeseed). For wheat, an estimate of the average increase in gross margin compared to an equivalent unmanaged situation can be made, giving an estimated increase of about **25 to 35 €/ha**. For rapeseed, precise calculations made by the Epis-Centre cooperative following the 2003 campaign led to the following results:

- **Yield gain** : 1.9 q/ha on average,
- **Saving in nitrogen** of 30 units on average,
- **Increase in gross margin** : 53 €/ha on average, (83 €/ha for heterogeneous plots)
- **Reduction in nitrogen budget** (input/output) of 35 units.

Protection of the environment through the development of respectful farming practices which comply with the requirements of the new common agricultural policy: Farmstar has been approved by the Ministry of Agriculture and the Chamber of Agriculture.

For cooperatives, more precise knowledge of all plots in the area for which they are responsible.

Source: <http://www.spotimage.fr/web/en/640-precision-farming.php>

Exhibit 12: Testimonial on the Success of Farmstar

Bernard COQUIL, head of the Farmstar project at EADS/Astrium:

"The 2004 campaign has been a success. Spot image contributed its expert know-how to provide quality images in time...." The lessons of the 2004 Farmstar campaign for **Epis-Centre**. This cooperative in the Cher is the leading user of Farmstar for monitoring cereal and rapeseed crops by means of satellite imagery and aerial photographs. For the 2003/2004 campaign, 800 farmers, working 37,000 ha, use the method. One of the lessons of the current campaign has been that **28% of the plots monitored do not require a third application of nitrogen**. (Technology watch thread for agricultural internet – n° 119 – 14 May 2004)

Conférence de presse FARMSTAR du 05 septembre 2008 Maison des Pyrénées Atlantiques - Paris

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