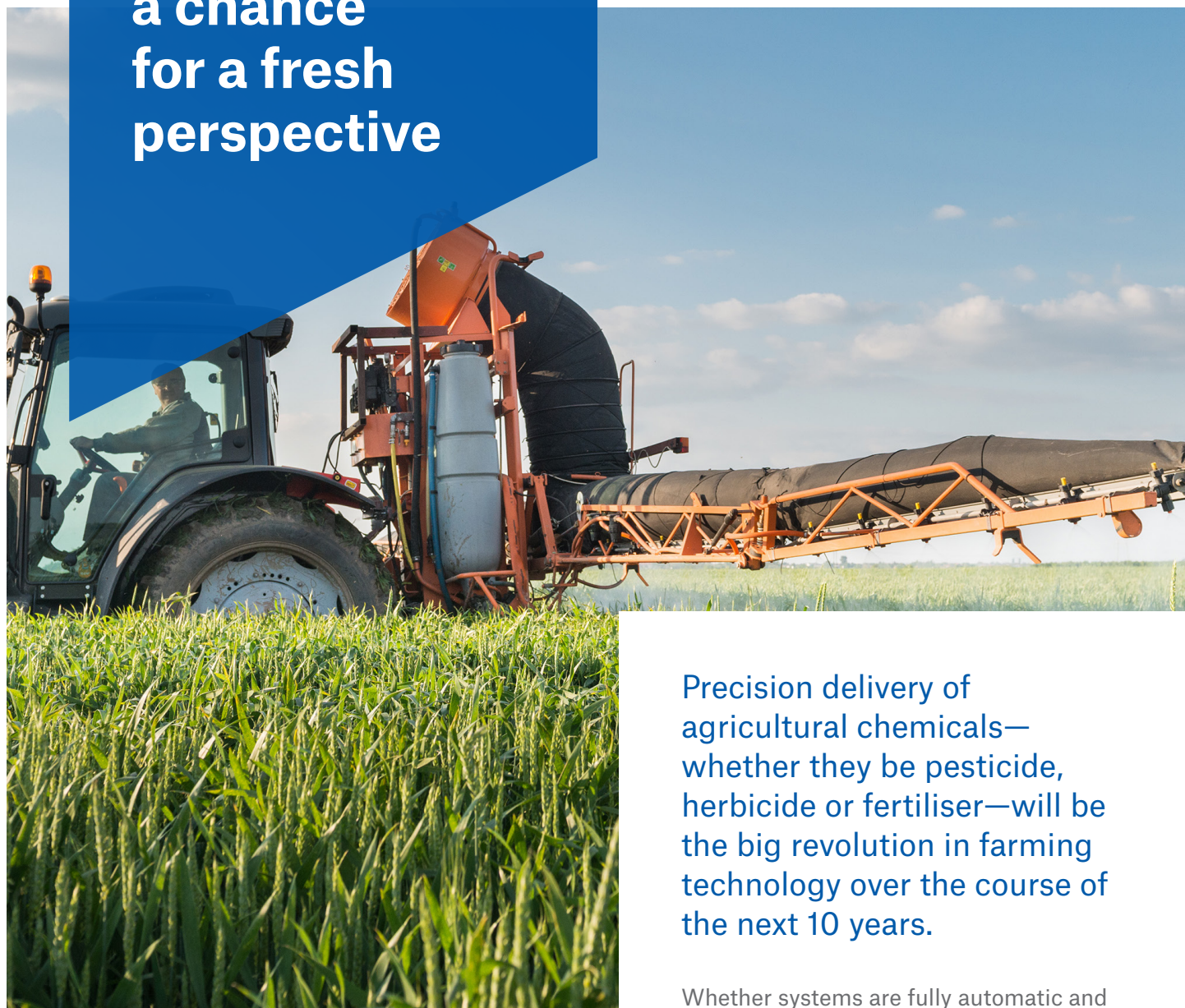


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Precision delivery: a chance for a fresh perspective



Precision delivery of agricultural chemicals—whether they be pesticide, herbicide or fertiliser—will be the big revolution in farming technology over the course of the next 10 years.

Whether systems are fully automatic and robotic, or still pulled behind a human operated tractor, it seems inevitable that the future of agrichem lies in smaller doses of highly concentrated, highly effective chemicals, delivered to the square centimetre where they are most needed. Product developers should take this opportunity to re-imagine basic assumptions regarding chemical delivery to the field.

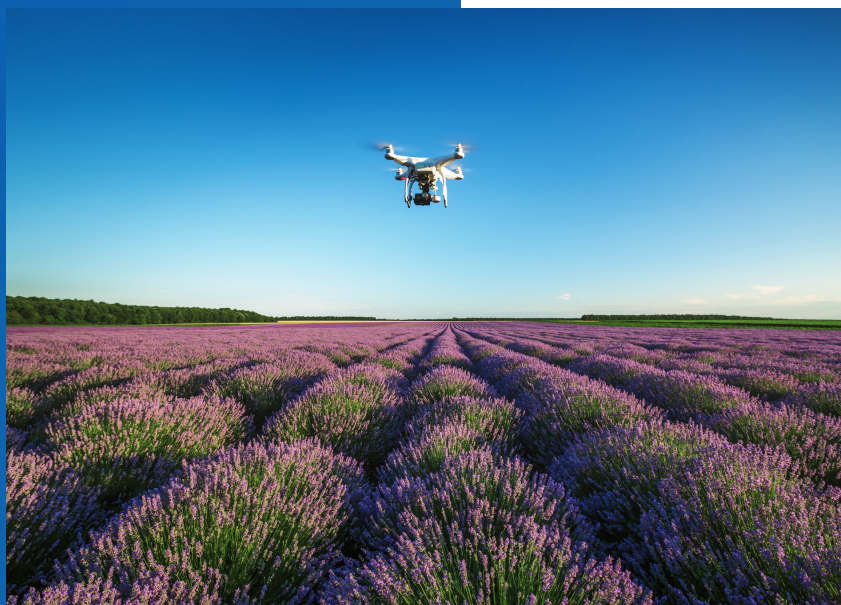
By interrogating some of the fundamental assumptions, we can unlock new user benefits and new ways of thinking.

The advantages of such precision are immediately clear: lower overall doses of the chemical across a field mean a reduced likelihood of unwanted environmental exposure and leaching into the water supply.

Already many firms are considering the potential to revive products which had previously been phased out due to environmental concerns and regulatory pressures. This is especially important given the high efficacy of these legacy products and the huge costs involved in developing new formulations and bringing them to market.

At Sagentia, our experience in developing custom devices integrating highly specific fluidic delivery systems across agricultural, industrial, consumer and medical sectors leads us to have a unique perspective on many of the challenges affecting the development of precision agriculture systems. We believe that by interrogating some of the fundamental assumptions and paradigms of these systems, we can unlock new user benefits and new ways of thinking.

This is already being seen by the work we're doing with clients in this sector who are capitalising on our science-based insight and cross-industry expertise to deliver products that create commercial value and competitive advantage.



The harsh reality of precision spraying

Automated precision delivery systems are, unsurprisingly, not simple to design and build to specification. They tend to be large, complex, electromechanical devices, requiring some level of weed (or invasive pest) recognition, coupled to a method to dose chemical remediation at the exact point of interest. As we develop more sophisticated systems, analytical and algorithm complexity is ever increasing: technologies could be built on simple, legacy techniques

such as colour discrimination, but more likely require modern methodologies such as hyperspectral imaging or data analysis using complex statistical regimes like machine learning. With the increase in complexity of the control systems and analysis, it becomes more difficult to simulate, test and outright prove the accuracy of the delivery, and so sophisticated droplet tracking and validation techniques are also necessary.

In order to unlock the potential regulatory benefits offered by precision delivery regimens, the systems must be able to trace and record that the minimum levels of chemical remediation have been used to treat the problem, and that all of the dosed product is delivered to exactly the point of invasive challenge.



Precision farming market was valued at \$4.42bn in 2017 and is projected to reach \$9.53bn by 2023.¹

Precision delivery regimes rely on using small amounts of high concentrations of highly effective chemicals; if there is any deviation from the planned delivery, high value crops may be negatively affected, or the product may enter the general environment, undermining the regulatory claims.



In particular, for sprayed chemicals, there is potential for challenges after the formulation droplet exits the machine. Spray drift may not always be easy to predict and model given real world, gusty or swirling wind conditions. After the droplet has landed, there are further potential challenges of splash back and the formation of ultra-fine droplets which can be picked up by the wind and uncontrollably spread through the field and the

wider environment. These challenges might be mitigated by intelligent equipment design or reformulation, but we recommend that product developers should see precision delivery systems as a chance to re-examine certain paradigms.

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New delivery paradigms

Historically, equipment designs and chemical products were developed with one purpose in mind—the blanket coverage of large tracts of land with a high-volume, low concentration specific formulation, controlling the growth of invasive pests whether they were present or not. As we have moved to targeted delivery, it is a good time to consider if the product format is still the right one. Specific situations might warrant a novel formulation, or we may unlock new product benefits by delivering chemical remediation in new ways.

Foams could be generated by the entrainment of air at the point of dispense, or by using a chemical gas generation technique like that used in home cleaning products.

Sagentia has identified a number of potential options to deliver products which are not currently supported by manufacturers of formulations or machinery, but which could provide new and novel benefits on the ground:

- Solid Particles: for example, zeolites or bentonite clay particles. These inorganic materials can be synthesised with specific particle sizes and tend to be highly absorptive of chemicals of interest, allowing the product to then slowly leach out into the soil as a treatment. Solid particles give the advantage of structural integrity to the delivery system, mitigating issues surrounding splash, drift or ultrafine droplet generation, however, care must be taken to ensure that the delivery particles are suitably degradable in the field; the system should aim to ultimately add to soil quality over time.
- Foaming delivery: foams have long found use in consumer and commercial applications to ensure that useful chemicals remain in position against the action of gravity. The high surface area, surface tension effect and low weight of bubbles enable them to cling to areas where a conventional water droplet would run straight off. Foams could be generated by the entrainment of air at the point of dispense, or by using a chemical gas generation technique like that used in home cleaning products. This method of delivery might present a unique opportunity for specific pesticide activity on stems and leaves of high value crops. Challenges will remain on the ability of an automated system to deliver the foam formula to the specific area of interest, which may be covered by other leaves, flowers, and growing fruit: the delivery mechanism will need to be highly flexible.



An estimated three million cases of pesticide poisoning each year lead to nearly 220,000 deaths, primarily in developing countries.²

- High viscosity delivery remains a hugely interesting topic for precision delivery systems: the physics affecting droplet breakup and splashing are viscosity dependent, so optimising the fluidic properties of the chemical formulation might help with mitigating the risks of ultrafine droplets and drift. With certain viscosity modifiers—particularly shear thinning additives—it may be possible to spray a liquid formulation that becomes more solid upon deposition. Long term and sustained release of chemical actives has been a research target for a number of years, especially within the medical industry: product developers in agricultural sectors might build on that knowledge to create solutions which give a long term protective solution to crops.

One known challenge for these techniques has been the speed of treatment, but as unmanned robotic options become more common, machinery could run automated through the night.

- Frozen droplet delivery may be an attractive format for material delivery; combining as it does the advantages of a solid delivery format (with minimal potential for splash back) with the advantages of conventional liquid delivery, with no further residues left in place at the delivery site. Generating frozen droplets on demand and at the point of dispense might involve novel nozzle design. This would be required to allow for fast and controllable chilling of any formulation or for the use of super cooled gases to freeze the droplet as it is sprayed.
- These potential delivery routes, of course, still assume that the best precision delivery systems will look to deliver chemical remediation options to the crop—increasingly, product developers are looking outside the traditional chemical options for solutions based on energy delivery from high intensity optics, high voltage electricity or straightforward high velocity impacts. One known challenge for these techniques has been the speed of treatment, but as unmanned robotic options become more common, machinery could run automated through the night; slower “per hectare” machinery might be acceptable.



Further, as we look to the next generation of bioremediation options, we must consider the needs of sensitive and high value biologicals, which may not respond well to traditional delivery methods.

Sagentia is well placed to be the premier product development partner for the precision agriculture industry. From ground based sensors, communication systems, machine vision and bespoke AI implementations to robotic, automated, precise dispensing systems, we have the experience to bring the next

generation of agricultural systems to life. Leveraging expertise in sensing and algorithm development for highly regulated sectors such as the medical device industry, with the experience of developing ruggedised systems for heavy industry, the Sagentia team can build the right system for the challenges.



Breakthroughs in nutrition, genetics, informatics, satellite imaging, remote sensing, meteorology, precision farming and low impact agriculture are driving major global investment in agri-tech.³

30-40%

of total food production is lost before it reaches the market

Impact on the ground

One thing product developers must of course bear in mind is that machinery and treatment options do not come for free. For every custom option for every different crop, a farmer must make the active choice to invest in a new equipment architecture. We must make every attempt to make new products as flexible as the traditional option of blanket spraying; the high capital cost of new equipment does not support separate solutions for separate problems.



Modular approaches may be possible—where dispensing elements of the system can be hot swapped for the specific challenge but other components (navigation, detection, control systems) are common across crop types, geographies and use cases. Modularity can provide the “best of both worlds”, but requires a strong vision from the machinery manufacturers—systems need to be holistically designed from the very start, or else key performance attributes will be sacrificed.

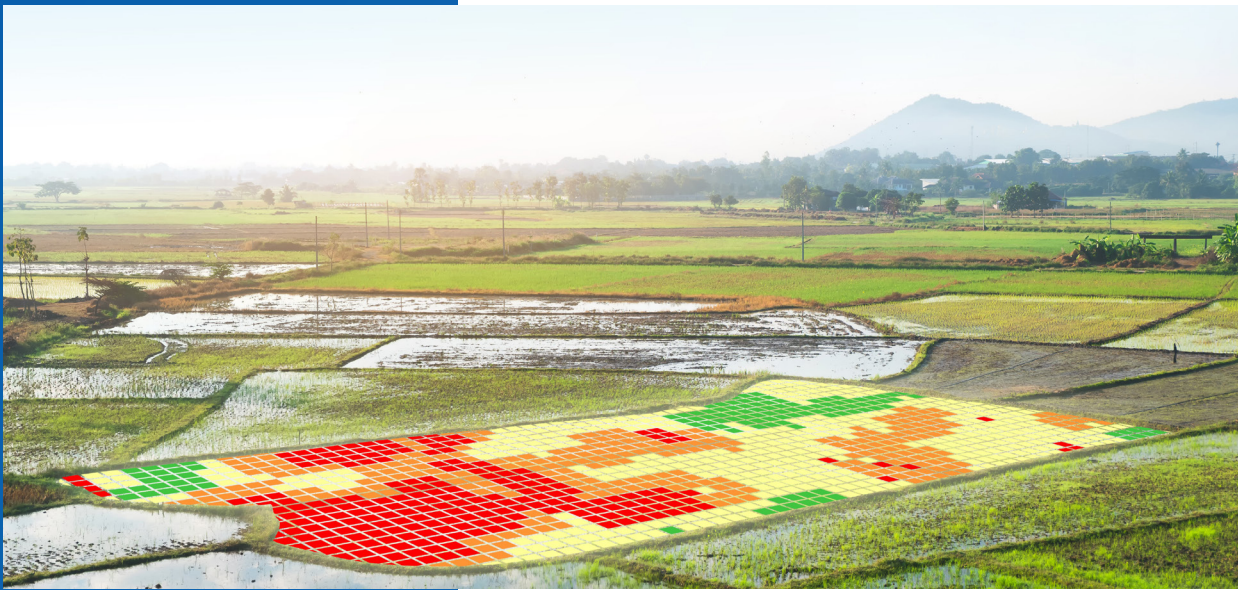
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Wider perspective

Much of this discussion on pesticide or herbicide delivery is matched in nutrient delivery—the 4Rs of nutrient stewardship (Right Source, Right Rate, Right Time, Right Place) suggest a solution which relies upon technology deployment to sense and deliver nutrients to the point of need; mitigating inefficiency and nutrient losses from over-delivery. Further, we see strong parallels with the ongoing development for on-the-ground sensing options. Smart irrigation systems are beginning to reach markets, giving farm managers up to date information about the ground state and automatically taking steps to deliver water (potentially including the nutrients) to the areas of need.

Any automated or precision delivery system is likely to require substantial sensing capability on board.

Further inputs to the precision delivery planning picture come from the ongoing development of remote sensing systems; primarily driven by advances in drone systems and high quality, potentially multi- or hyper-spectral imaging systems. These systems will enable better foresight on the ground, allowing farm managers to plan and prioritise the deployment of machinery across a large area of land to “hotspots” of trouble. However, any automated or precision delivery system is likely to require substantial sensing capability on board: the resolution and accuracy of remote sensing systems is not granular enough to guarantee perfect, precise and complete coverage of weeds, pests or poor quality soils.



The integration of predictive analytics and sophisticated management software into the day-to-day workload planning at a farm will also become part of an approach to overcoming regulatory burdens. If the promise of precision delivery is fully realised, powerful legacy chemicals may return to the market; however, regulators may require individual farmers to hugely increase their reporting and compliance regimes.



Predictions show almost a half a million drones in action by 2020.⁴

To avoid unnecessary burdens being placed on the farmers, precision agriculture product developers should be prepared to monitor, record and prove the delivery regimes meet the guidelines, likely by connecting back into the farm management software systems. More novel delivery formats will assist in tracking and traceability of delivery—indeed, systems can be envisaged whereby the correct delivery format is chosen based on systematic risk profiles within a complex regulatory environment.



Conclusions

In any industry, when fundamental paradigms are in flux, as they are across the agricultural sector, and longstanding practises are beginning to change, it is important to take a step back and consider which of the fundamental assumptions underpinning the market are no longer the solid and immutable requirements that they once were. As we look towards a new ideal for product delivery to the field, we are given the opportunity to develop new product formats which better solve the challenges of today.

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¹ [Source: 2018 report by MarketsandMarkets]

² <http://www.fao.org/docrep/004/y3557e/y3557e11.htm>

³ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/227259/9643-BIS-UK_Agri_Tech_Strategy_Accessible.pdf

⁴ <https://www.forbes.com/sites/jenniferhicks/2018/04/30/why-precision-agriculture-will-change-how-food-is-produced/#283bc4fb6c65>