UK-Canada Symposium on Smart Technologies for Sustainable Agriculture

SYMPOSIUM REPORT

18-20 January 2016

High Commission of Canada

London, UK

UK Science & Innovation Network

Government of Canada
High Commission of Canada

Gouvernement du Canada
Haut-commissariat du Canada

McGill University

Harper Adams University

Cranfield University

CATAPULT Satellite Applications

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Executive Summary

Precision Agriculture (also known as smart farming) refers to techniques to increase crop productivity while conserving their resources by taking account of within-field spatial variability in soil, crop and environment. These technologies include automated navigation, soil and crop sensing, remote sensing, variable rate application of inputs, modelling of agricultural processes, the optimization of farming logistics and agro-robotics. Given the heightened concern for global food security, it was timely to continue to investigate potential partnerships between the UK and Canada following an earlier workshop in Montreal in July 2014.

This was undertaken in a 1 ½ -day workshop at the Canadian High Commission in London, 18-19 January 2016, followed by ½ -day visits to both Cranfield and Harper Adams Universities. The purpose was to explore future research and development, education and training, data sharing and business opportunities where co-ordinated programmes could benefit both nations. Approximately 60 participants joined in the main component of the programme, with 15 Canadian participants travelling to Cranfield and Harper Adams Universities with their UK hosts.

Since the 2014 Montreal Workshop, there have been significant changes in both the UK and Canada with respect to the importance of agriculture and food. This is reflected in the announcements of agri-tech and Catapult centres and new funding opportunities via UKTI, BBSRC and the Agriculture and Horticulture Development Board in the UK and NSERC and the provincial research funding agencies in Canada. Representatives of the above were encouraging parallel funding of co-ordinated programmes.

At the conclusion of the technical debates (Sessions I – IV) on the first day, it could be argued that many of the technical challenges reported at Montreal still exist but some progress had been made and the focus now was clearer. With the advent of opportunities for the funding referred to above, future progress was expected to accelerate. This could be most effectively conducted in the area of joint research and training, with data exchange at the current time being effectively a component of research. A number of opportunities for joint business ventures were identified. However, due to both the interests of the candidates present and the sensitivity of business ventures, these were discussed in the broadest terms as potential opportunities.

The top issues for joint research focused on further development in soil sensing (including biological condition), weed control techniques, crop protection and nitrogen management and robotic applications. With developments in the capture of more agronomic, economic and environmental data (‘big data’), the concept of co-ordinating pilot programmes in both the UK and Canada had particular resonance. This nicely linked two of the objectives of research and data exchange. A number of tentative agreements for presentations at farmer/extension worker training events were made between individuals. The UK and Canadian universities agreed to co-ordinate, where

possible, educational experiences for graduate students and research staff. Business opportunities in the areas of variable depth tillage techniques, alternative weed control methods, residue sensing and data collection were considered as having potential that is worthy of future investigation.

Introduction

With a number of similarities in the way smart technologies are adopted in both Canada and the UK, it is important to increase collaboration awareness and share successful developments between Canada and the UK. Different smart farming technologies, which are popular today, have been developed in both countries since the beginnings of precision agriculture in the 1990s and different academic institutions as well as technology and service providers are world leaders in certain areas. Currently, due to the emerging concern for global food security, there is growing public interest in technological innovations in agriculture.

For this reason, this symposium has been organised to continue the dialog commenced in the Montreal Workshop in July 2014, to seek ways to strengthen on-going technology developments, evaluate the potential for markets for precision agriculture in both countries as well as considering better ways to export UK/Canada-based products and services to other countries. In terms of future collaboration, four areas of common interest can be defined:

Training. Professional training of farmers, contractors, advisers and researchers, would improve commercially available solutions. Furthermore workshops, such as this one, enhance information exchange which stimulates novel thinking and the constructive evolution of existing practises as well as planning upcoming developments.

Joint research and product development. Due to similarities in terms of crop production and the adoption of technology in parts of the UK and Canada, joint research programs would be very beneficial to further collaboration.

A common data exchange hub. A shared data space to exchange measured crop response characteristics appears to be a well-suited first-in-line program that is of interest to researchers and service providers on both sides of the Atlantic.

Joint business ventures. It would be attractive to study the potential joint business opportunities when technologies originating from one country compliment emerging practices elsewhere.

Based on the workshop results, it follows that the UK, Canada and other countries are faced with the need to explore suitable options in each of these four categories. Joint efforts may help preserve resources, add versatility and enhance the exchange of expert knowledge.

Symposium Summary

Participants were welcomed to the workshop by Mark Richardson (Senior Trade Commissioner at High Commission of Canada) who also recognised the generous funding from the UK Science and Innovation Network. Joint chairman, Dick Godwin, recalled the successful first joint workshop held in Montreal in July 2014. The workshop was intended to be an informal interchange between UK and Canadian delegates on business, research, training and data exchange opportunities in the area of precision agriculture, also known by some as 'smart farming'. Each participant briefly introduced themselves. Joint chairman, Viacheslav Adamchuk, also welcomed participants and indicated the program to be followed on the 3 days of the workshop. Day 1 started with panel presentations in 4 topic areas followed by discussion from the floor (organised below into topic areas). Panel members provided brief printed handouts. Day 2 was given over to integration and synthesis of discussions. Day 2 and 3 included visits to Cranfield and Harper Adams Universities.

Session I: Agricultural Automation and Robotics – Fiction or reality?

Moderator: Sven Peets

Panel member contributions

Simon Blackmore (Harper Adams University, UK)

- Small robotic machines to intelligently manage crops individually.
- Autonomous tractor using laser weeding or mechanical weeding.
- Herbicide can be reduced by 99.99% with individual leaf application.
- 'We can measure everything we want to measure – but is that sensible?'

Viacheslav Adamchuk (McGill University, Canada)

- Individual plant management.
- Strip tillage + auto-guidance.
- Problems with RTK GNSS.
- Robotics – agricultural environment is 'dull, dirty, dangerous'!

Jordan Boyle (University of Leeds, UK)

- Concept of 'Free-range robotics'.
- Using living things (e.g. invertebrates) to direct/inspire robotic development.
- Pollination of high value crops/weed/pest control.

Qumar Zaman (University of Dalhousie, Canada)

- Smart sprayer development with image analysis for crop/weed discrimination.

Discussion from floor

1. Small robotic machine to intelligently manage crops, plant by plant (assume high value crops?)

'Free-range' robotics modelled on living organisms such as invertebrates

Control of robots – safety concerns. Human intervention must be part of the system
Robotics for pre-plant operations such as tillage and side-dress fertiliser
Can robotics be used in soil remediation

2. Automatic control of field machines

- Auto-guidance
- Smart sprayer incorporating image analysis for weed/crop discrimination
- More efficient harvesting mechanisms – reduce grain loss
- Robotic scanning to map grain loss

3. Farmer response to automation

- Younger, more highly-qualified farmers
- Agricultural production is about risk minimisation. Will farmers spend on hi-tech?
- Social acceptability of robots?

4. Likely uptake of robotics

- Robotic weeding, selective harvesting in 5-10 yr

Session II: Sensing of Soil and Crop – Satellite, drone or sensing on-the-go?

Moderator: Viacheslav Adamchuk

Panel member contributions

Toby Waine (Cranfield University, UK)

- Poses a question – ever higher resolution (spatial/temporal) data will improve efficiency. Is this true and is there an optimum?

Asim Biswas (McGill University, Canada)

- Also posed a number of questions about sensors –
- On-the-go sensors – how useful? Good data? How repeatable?
- Data quality vs amount of data? Cost of data?
- Sensor durability? Data from multiple sensors? Sensor fusion?
- Data to information?

Vladimir Stoiljkovic (Satellites Application – Catapult, UK)

- Satellite data – extensive coverage (4 M km^2 per day) – what value in agriculture?
- Can SAR data provide useful information for agriculture?

Alex Melnitchouck (Bayer CropScience, Canada)

- Extracting data at field scale from 'global data'.
- Making layers of info.
- How to integrate RS data with ground-collected data.

Abdul Mouazen (Cranfield University, UK)

- Multi-sensors data fusion.
- Soil sensors.
- On-the-go sensors.
- Multi-layer maps.
- Generating N application maps.

Moderator's summary

- Remote sensing very important in Canada.

- UAVs as versatile sensor carriers.
- Temporal variability is as important as spatial variability.
- Can farmers afford data?

Discussion from floor

1. Ever higher resolution temporal & spatial data. How high do we need? – from satellite, near-ground & in-situ sensors
- Sensor resolution must be related to application equipment resolution
- Must be related to SV scale
- Depends! (mentioned that N varies even at the leaf scale)
- Increasing resolution is costly – must be related to equipment capability
- Larger machines (so increasing width) – losing resolution for variable application?

2. What should we sense?
- Understanding of the soil-crop-environment system is lacking in the spatial realm.
- So what do we measure?
- What factors affect – and limit – yield? We should measure these. Again, our understanding of the system is limited.

3. We have many 'data layers'. These must be integrated to provide usable information.
- How to integrate remote-sensed and ground collected data?
- If we are missing one data layer, we are missing everything!
- The weakest link is the coarsest layer of data
- On-the-go sensing must be complemented by historical data layers (both recent and older historical data)

4. What does the farmer need?
- Simplest system possible!
- Data/info is the tool to enable the farmer to make intelligent management decisions
- Yield limiting factors must be known
- A good field agronomist to interpret the data or could an 'intelligent advisor' app on the farmer's smart phone do?
- Confidence in the data – uncertainty in data leads to uncertain decision making!
- Accurate yield sensing (yield affects every other decision)

Session III: Fertilizer and other agro-inputs – Varying for profitability or environment?

Moderator: Richard Godwin

Panel member contributions

Paul Miller (Independent Consultant, UK)
- Chemical control here for 10 yr+.
- Losing registration of products at a high rate.
- How PA can help – minimise dose + selective application.
- What does the target need?

- Concerns – runoff, losses.
- Regulators subject to environmental restraints.
- Timeliness critical – delay 3 days=economic loss.
- More emphasis on plant protection products.

Bernie Zebath (Agriculture and Agri-Food Canada)

- Potato production in Atlantic Canada. Challenges include pests, disease, declining OM, Ground water contamination.
- Mapping soil properties, soil health and quality
- How do we map soil and crop variability?
- Once mapped – then what?

Nicolas Tremblay (Agriculture and Agri-Food Canada)

- N management in corn.
- Crop managed spatially for profit & environment.
- Weather uncertainty. Precision precipitation prediction needed.
- Temporal variability (season to season) more important than spatial variability.
- Vegetation sensing is important.
- PA is not up to expectations.

Shamal Mohammed (GeoInfo Fusion Ltd, UK)

- How to reduce complexity - N rate difficult to determine for VRT.
- Need for cheap and plentiful sensors for continuous sensing.
- Specific input indices to quantify input requirement (beyond NDVI).

Bill Deen (University of Guelph, Canada)

- Long-term N rate trials. Predicting N requirement ahead of application.
- Under-seeding wheat with red clover benefits.
- How accurate do rates have to be (flat topped response curve.)?

Discussion from floor

1. Chemical control of weeds/pests

- Here for at least 10 yr
- Product registrations being lost at high rate
- PA to enable dose minimisation and selective application
- Regulators are guided by environmental restraints – not by crop requirement
- Timeliness critical

2. Fertiliser application

- SV management of N can meet both profit & environmental targets
- Largest uncertainty is weather so temporal (season to season) variability more important than SV
- Precise prediction of precipitation required
- On site (- or field) weather stations improve prediction
- More accurate (and local) weather stations for radiation & precipitation
- Management zones too restrictive (‘Mother Nature doesn’t work in MZs’!)

3. Questions/comments on N

- Is N the limiting factor
- Where does N go?
- Determining N rate for VRT is difficult
- Do N rates have to be precise? (flat-topped response curve)

Session IV: Irrigation, drainage and soil management

Moderator: Paul Miller

Panel member contributions

Mark Else (East Malling Research, UK)

- Precision irrigation & fertigation on soft fruit crops.
- Plant resilience to extreme weather events.
- Sensing stresses on crop – biotic and abiotic.
- Sensing fruit quality non-destructively.

Chandra Madramootoo (McGill University, Canada)

- Precision irrigation using timely and targeted information.
- Management zones based on elevation + soil EC.
- Integration of meteorological, soil and environmental data.
- Use of sensors to increase water use efficiency, manage soil salinity, conserve water.

Jean Caron (Université Laval, Canada)

- Wireless soil sensors for variable rate irrigation.
- Variation of soil matric potential through growing season.

Richard Godwin (Harper Adams University, UK)

- Soil compaction reduces yield, increases draft force, reduces infiltration rates.
- Compaction costs > £1b/yr.
- Controlled traffic farming leads to 8-35% yield increase (wheel ways still a problem).
- Equipment design needs, sensors for compaction.

Discussion from floor

1. Irrigation

- Precision irrigation and fertigation in high value fruit crops (price of raspberries: £6k / t)
- Irrigation management zones can be based on elevation and soil EC data
- Sensors required to increase water use efficiency, manage soil salinity, conserve water
- Wireless network soil sensors can be used for irrigation control

2. Soil management

- Compaction is main area of concern
- Compaction reduces yield, increases draft force, affects infiltration rate, destroys soil structure
- Compaction costs £1 bn / yr
- Controlled traffic farming benefits: 8-35% yield increase, greatly reduced tillage forces, improved soil structure (but wheel ways can cause problems)

3. Sensing needs

- Biotic/abiotic crop stress
- Fruit quality non-destructively
- Compaction
- Soil bulk density
- Plant water stress
- Salt stress
- Soil moisture tension, wetting front.

Highlights of Day 1

Maurice Maloney (Global Institute for Food Security, Canada)

- The development and application of robots
- Precision seeding and fertilisation
- Alternative weeding techniques
- Soil sensor development
- Improved image analysis techniques
- Techniques for improved animal husbandry for health and milk yield.
- As applied to arable and horticultural crops, dairy and livestock production.

Recommendations

Integration and synthesis of discussions: Business opportunities

Moderator: Clive Blacker

Opening comments: Many problems and ideas raised in sessions. What does each have to offer? Can these be combined to make a more attractive offer? Where does funding come from?
Suggestions:

- Soil damage from precipitation impact on soils a worldwide problem (requirements for cover crop, residue left after harvest).
- Data sharing, food safety projects.
- Supply chain for agriculture.
- PA services including satellite imagery.
- High resolution soil mapping.

Integration and synthesis of discussions: Research opportunities

Moderator: Bill Deen

Opening comments: PA for sustainable intensification. Measurement of yield at higher resolution. PA and CTF. Crop protection. N management – weather prediction.
Suggestions:

- Farm system is part of environmental system – minimisation of environmental impact is part of agricultural production.
- How to adopt PA technology for soil management. Identify limiting factors. Quantify the economic benefits of PA in order to overcome barriers to adoption of the technology.
- Pilot study to test the potential of Big Data in improving decision making and farm profitability using very rich farm data from one in UK and one in Canada.
- Ground truthing 'real data', methods of acquiring relevant data.
- N use in cool climates. Combine protein sensors. On-farm experiment protocols with a non-classical statistical analysis.
- Funding: see Global Food Security Cross Council Programme. Call from AHDB in March for PA projects (http://www.foodsecurity.ac.uk/index.html)
- Uncertainty & Risk: Cross Council discussions and workshops - see announcements in Feb (https://www.epsrc.ac.uk/)

Integration and synthesis of discussions: Education and training opportunities

Moderator: Viacheslav Adamchuk

Discussion ranged over the types and style of these topics, with a perceived need for both:

- Research and development education for graduate students and researchers
- Practical training for farmers and advisers

There was a consensus that the former could be orchestrated through exchanges between the Canadian Universities of McGill and Guelph and the UK Universities of Harper Adams, Cranfield, Newcastle upon Tyne, Reading and Manchester depending upon the particular requirements and skill sets required. Viacheslav Adamchuk agreed to be the key contact for this activity. Assurance was given that funding for educational exchange could be available particularly for Canadian applicants wishing to come to the UK. Harper Adams University would welcome applicants on to either the MSc in Precision Farming (Sven Peets) or the MSc in Mechatronics (Simon Blackmore).

Funding for practical training for farmers and advisors would probably be most effective by the direct requests for “precision farming” experts to be individually invited to participate as speakers in the training sessions in either country. At the end of the workshop, at least one informal request was made for a UK speaker (Richard Godwin) to attend a Canadian farm extension event in Quebec in late 2016/early 2017. Others should follow. Simon Blackmore and Maurice Maloney had a number of conversations during the session at Harper Adams University to extend their dialogue into the application of robotics into plant phenotyping and related applications.

Integration and synthesis of discussions: Session IV - Data sharing opportunities

Moderator: Shamal Mohammed

This topic was, as expected, one where it was less tangible to assign direct outcomes. However the concept raised above in Research Opportunities in relation to the establishment of joint “pilot studies” to test the potential of Big Data in improving decision making and farm profitability could use very rich farm data from one in UK and one in Canada.

This captured the enthusiasm of the participants to wish to explore the idea further. This was very relevant given the recent establishment of Agrimetrics Ltd at Reading University (Richard Tiffin) where a farmer-led friendly approach was being adopted. This

could prove a valuable opportunity for parallel co-funding from NSERC and AHDB in Canada and the UK respectively.

One relevant comment was that it would be helpful for a “framework” agreement between the UK and Canada so that the timing of parallel funding opportunities could be co-ordinated.

Acknowledgments

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List of Participants

Name	Affiliation	Country
Viacheslav Adamchuk	McGill University	Canada
Louise Bermingham	Rezatek	UK
Asim Biswas	McGill University	Canada
Clive Blacker	UKTI	UK
Simon Blackmore	Harper Adams University	UK
Jordan Boyle	University of Leeds	UK
Robert Bradburne	*DEFRA*	UK
Jean Caron	Laval University	Canada
Jonathan Carruthers	Rothamsted Research	UK
Karem Chokmani	INRS	Canada
Bill Deen	University of Guelph	Canada
Andrew Diprose	Ubiqutek	UK
Sam Durham	National Farmers Union	UK
Tristan Eagling	KTN	UK
Mark Else	East Malling Research	UK
Richard Godwin	Harper Adams University	UK
Bruce Grieve	University of Manchester	UK
Bettina Hamelin	NSERC	Canada
Paul Harris	Glacier Farm Media	UK
Gareth Hector	Glacier Farm Media	UK
Paul Hutton	Cranfield Aerospace Ltd.	UK
Emma Hennessey	Deputy Head of UK SIN	UK
Sarah Jackson	MetOFFICE	UK
Maryse Lassonde	FQRNT	Canada
Jack Lomas	SenSat	UK
Chandra Madramootoo	McGill University	Canada
Caroline Martin	Canadian High Comission	UK
Geoff McBride	SFTC	UK
Theresa Meacham	BBSRC	UK

Name	Affiliation	Country
Alex Melnitchouck	Bayer CropScience	Canada
Aubert Michaud	IRDA	Canada
Paul Miller	Independent Consultant	UK
Shamal Mohammed	Consultant	UK
Maurice Moloney	Global Institute for Food Security	Canada
Abdul Mouazen	Cranfield University	UK
Justine Pawelec	Quebec Delegation to UK	UK
Sven Peets	Harper Adams University	UK
Tony Pridmore	University of Nottingham	UK
Paul Raymer	Practical Precision	Canada
Mario Rivero-Huguet	British Consulate	Canada
Awan Sajjad	AHDB	UK
John Stafford	Silsoe Solutions	UK
Vladimir Stoiljkovic	SA Catapult	UK
Stewart Sweeney	OMAFRA	Canada
James Taylor	Newcastle University	UK
Richard Tiffin	University of Reading	UK
Nicolas Tremblay	AAFC	Canada
Toby Waine	Cranfield University	UK
Elizabeth Warham	UKTI	UK
Alan Weston	SenSat	UK
David Whattoff	SOYL	UK
Steve Wood	Digital Catapult	UK
Qamar Zaman	Dalhousie University	Canada
Bernie Zebarth	AAFC	Canada

E-mail listserve: *ukcaworkshop@lists.mcgill.ca*