



# Exploiting Sensors & ICT to "Change the Rules of the Game" for Global Agriculture and Food Security

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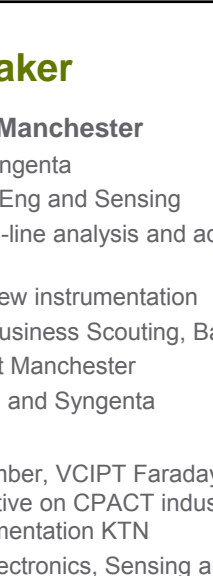
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**Exploiting Sensors and ICT to  
“Change the Rules of the Game” for  
Global Agriculture and Food Security**

Dr Bruce Grieve, Syngenta Sensors Centre  
Information, Instrumentation & Intelligence in R&D Management  
The University of Manchester, 14:00, Thursday 1<sup>st</sup> July 2010  
[www.manchester.ac.uk/eee/e-agri](http://www.manchester.ac.uk/eee/e-agri)



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**Bruce Grieve - Speaker**

- **Director of the Syngenta Sensor Centre, Manchester**
  - ~20 years with ICI, AstraZeneca and then Syngenta
  - First degree in Electronics, PhD in Chemical Eng and Sensing
  - Career in industry based upon introducing on-line analysis and advanced control to chemical production
  - History of University partnering to research new instrumentation
  - 2004 - Started working with Syngenta New Business Scouting, Basel
  - 2007 - Left Syngenta to set up the first UIC at Manchester
  - Supported by Royal Academy of Engineering and Syngenta
- **Process Monitoring & Sensors**
  - **Previously:** INTERSECT Faraday board member, VCIPT Faraday industrial board member, Zeneca representative on CPACT industrial steering team, Chair of the Sensors & Instrumentation KTN
  - **Currently:** Advisory Board member of the Electronics, Sensing and Photonics KTN; Chair of the IET Meas., Sensor, Instr. & NDT Exec.

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## Syngenta - Sponsor

- Syngenta is a world leading agribusiness
- Employs over 22,000 people
- Has over 300 sites in more than 90 countries
- Sell products in over 120 countries, touching almost 95% of the world's population
- Annual sales were \$9.3 billion in 2007
- Invested >\$900m in R&D in 2009













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## What Syngenta does


Crop Protection







Seeds

Lawn and Garden






Business Development



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# The Motivation





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## “The Perfect Storm”; Agri-Food challenges ...





- **Climate Change** – Drought in 2007 affected many countries and led to supply shortages. A wet summer in Western Europe led to disease pressure and reduced yield. Agriculture currently uses 70% of total global freshwater\*.
- **Population Demographics** – The world population is forecast to grow from 6.5B to over 9B by 2050\*\*. Increasing wealth is favouring high protein diets requiring 6-10 times the arable land as a vegetarian diet.
- **Limited land** – Few countries have more land available for agriculture. Modernisation in places such as Eastern Europe will help produce more food from available land.


\* Source: WBCSD    \*\* Source: US Census Bureau




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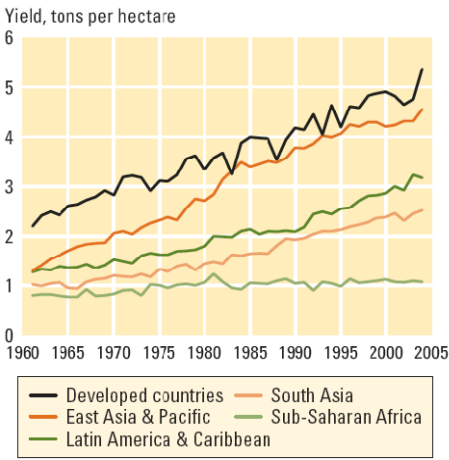
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## ... but further yield increases needed and possible




Yield, tons per hectare




Year	Developed countries	East Asia & Pacific	South Asia	Latin America & Caribbean	Sub-Saharan Africa
1960	2.5	1.5	1.2	1.0	0.8
1970	3.2	2.0	1.5	1.2	0.9
1980	3.8	2.8	1.8	1.5	1.0
1990	4.5	3.5	2.2	1.8	1.1
2000	5.0	4.2	2.5	2.0	1.1
2005	5.5	4.5	2.8	2.2	1.1

Source: <http://faostat.iaa.org>, accessed June 2007.



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## What is Sustainable food production?

Strategies & Practices that promote the long term well being of the environment, society & the farming economy. *To meet the needs of the present without compromising the ability of future generations to meet their own needs*

Improved Productivity

Environmental Protection

Welfare of Rural Communities

Sustainable farming

Triple bottom line – Economic, Social, Environmental

\*Brundtland Commission Definition of Sustainable Development

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## What is in a typical carbon footprint?

~3 lb C/bu

### Conventional Corn (Iowa, Rain-fed, 175 bu/ac)

Category	Percentage
Fertilizer Application	37%
Nitrous Oxide	31%
Harvest & Drying	17%
Tillage & Other Operations	6%
& Crop Protection Application	6%
Seed & Planting	3%

Note: footprints can also be developed for water and other elements of sustainability

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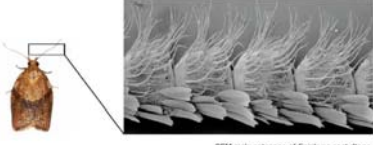
## Why are Sensors & Informatics of interest to Agri-Food?

Information will become more valuable than products alone ....

- E911 legislation now demands that every US mobile phone will have an integrated global positioning sensor
- Silicon is giving way to printable paper electronics making complex systems as cheap and mass producible as a simple 'post-it' note
- Whole cities in the US and the UK are now wirelessly enabled
- Wal-Mart® is dictating that their top 100 suppliers must use radio tagged goods
- Biotechnology is enabling the mimicking of the way Nature senses stimuli



Plastic Electronic Sensor Circuit



SEM main antennae of *Epiphyas postvittana*

Copying Nature's Way of Sensing

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## In 2007 the structured Landscaping process ...

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## Evolution of Syngenta's Open Innovation concept


- The Landscaping process
  - Maps out Syngenta's possible futures
  - *But how can they be technically delivered for non-traditional agri technologies?*
- Scouting exercise for how other companies 'acquired change'
  - In-house team: Slow to build, expensive and may never be critical mass
  - External acquisition: How can we just buy what does not yet exist?
  - The open innovation model†:
    - The Rolls-Royce Plc exemplar
    - Meeting in May 2006 – Eddie Williams of RR
    - No conflict of interest: RR = Aerospace, Syngenta = Agriculture

† Howells, J. (2004), *Innovation, Consumption and Services: Encapsulation and the Combinatorial Role of Services*, The Service Industries Journal, Pub. Frank Cass, Vol. 24, No. 1, pp 19-36

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## An Introduction to Landscaping


- **Technology Landscaping Exercises;**
  - 3 day structured workshops with ~60 people
    - Syngenta + External (80% : 20%)
    - Business & Technology (40% : 60%)
    - Global spread (EAME / NAFTA / APAC / LATAM)
  - 'Sensor science' addressed as theme in Schluchsee, May 07
- **(Insights ⇒) Breakthrough Questions ⇒ Innovation Statements**
- **Living long term maps that are augmented by re-applying "Breakthrough Questions"**
  - As market understanding develops and as technology progresses
  - Sensors have 7 Breakthrough Questions for Syngenta



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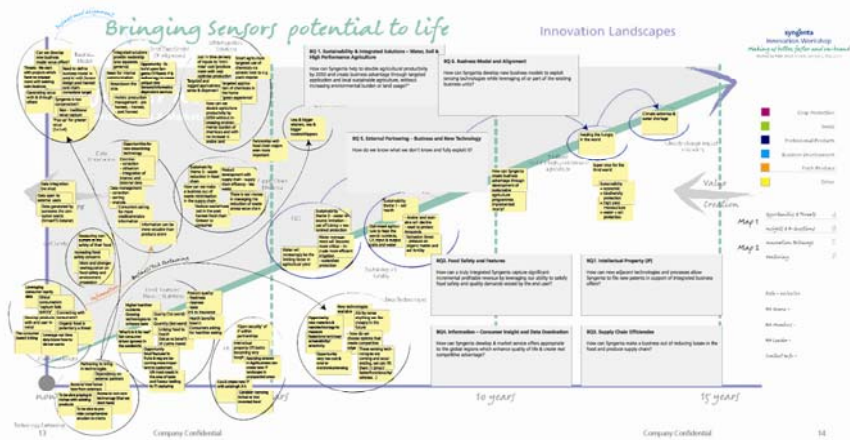



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## The Agri-Sensors Questions? A 15 year map of the needs & ...

Bringing Sensors potential to life





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**... a 15 year map of possibilities. The Agri-Sensors Solutions.**

Bringing sensors potential to life

Customer Value

Value Capture

Innovation Landscapes

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15 years

5 years

10 years

15 years

Company Confidential

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**... has lead to the University Innovation Centre concept**

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## The Generic UIC Model

- Aims to *integrate in non-conventional technologies from other sectors* to enable new ways of supporting global farming and food supply.
- Merge innovative agri-business models with an ability to deliver these enabling technologies.


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## The Structure of the UICs


1. Ring fenced group within a University environment
2. Accelerates knowledge transfer from academic groups which can then be integrated with the agri-industry's future commercial developments
3. Delivers *proof-of-concept* systems for field & market trials
4. Attempts to dovetail with public research initiatives (UK-Research Councils & Technology Strategy Board)
5. Creates *new technology supply chains* to source innovative technologies

- Now 6 Syngenta University Innovation Centres:
  - **Sensors (Manchester),**
  - **Systems Biology (Imperial),**
  - **Synthetic Chemistry (Shanghai),**
  - **Sugarcane Transformation (QUT),**
  - **Synthetic Chemistry (Wuhan)**
  - **Polymer Innovation (Warwick)**

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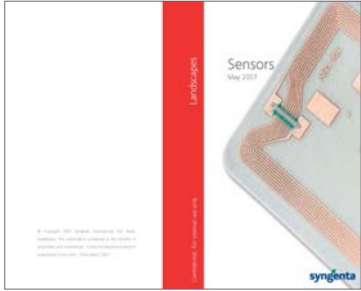


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# The Syngenta Sensors UIC at Manchester

Launched at the University of Manchester (UK) January 2007



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# Agri-Sensors: Where we are now


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## 0-10 yr “Innovation Statements” from 2007 Sensors Landscape

1. **Remote sensing for Home Care and Lawn / Garden**
  - a) Auto sense and dispense for Home Care and Lawn / Garden
2. **Non-specific in-field sensing of crop disease**
  - a) In-field specific detection and treatment of crop disease
  - b) In-field sense and dispense of CP products
3. **Sensing to manage agri water usage**
  - a) Sensing to manage plant and crop nutrients
4. **Early input trait selection**
  - a) Output trait sensing at point of sale
  - b) Early output trait selection
5. **Sensing for post-harvest supply chain management & waste reduction**
  - a) Pre-harvest detection of point of ripeness or crop senescence
6. **Tamper sensors for CP packs**
  - a) Foreign germplasm sensing

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## Current Research Portfolio in the Syngenta Sensors UIC

1. Early Fungal Disease Control through Wireless Networked Sensors
2. RFID-Sensors to reduce wastage in the Perishable Goods Supply Chain: Sub 5¢ printed sensor tags
3. Subsoil Imaging for Accelerated Breeding of Drought Tolerant Crops and Water Management
4. Breaking the barriers from farm to factory: Crop enzymatic expression sensing for 3<sup>rd</sup> generation biofuels
5. Propagation: Bud sensing for sugarcane
6. Crop Management: Weed sensing and micro-CP dosing for horticultural crops (mitigation for EU 91/414 legislation)
7. Harvest Management: Subsoil imaging for potato maturation
8. Energy harvesting for soil mounted sensors

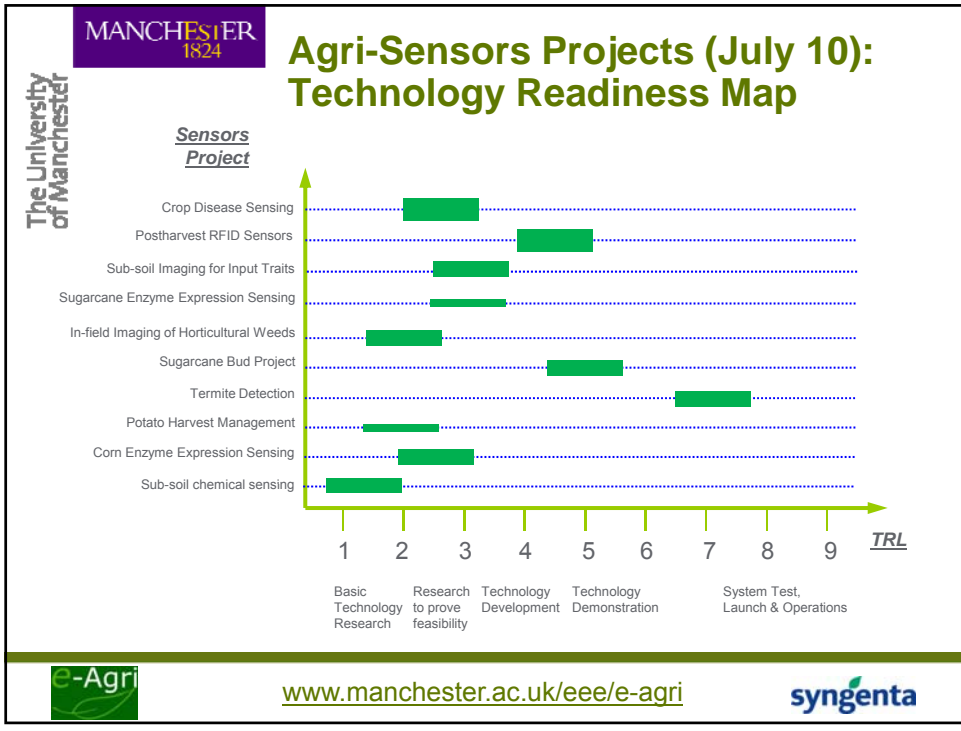
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## Populating the Sensors Landscape: Some Examples

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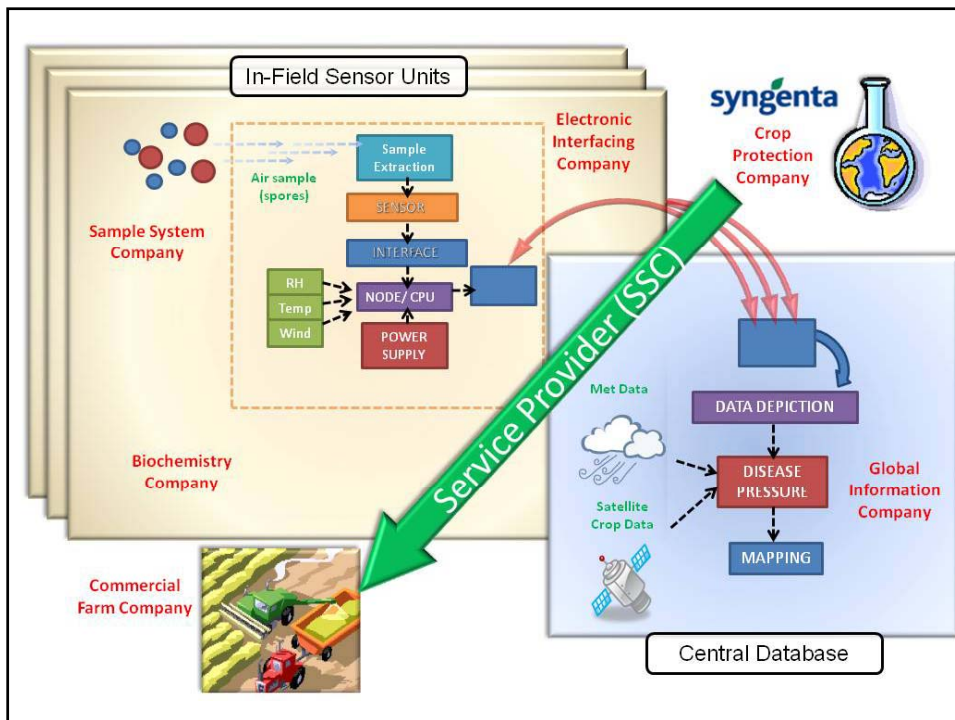


# 1: Early Detection of Crop Disease & Pest Infestation

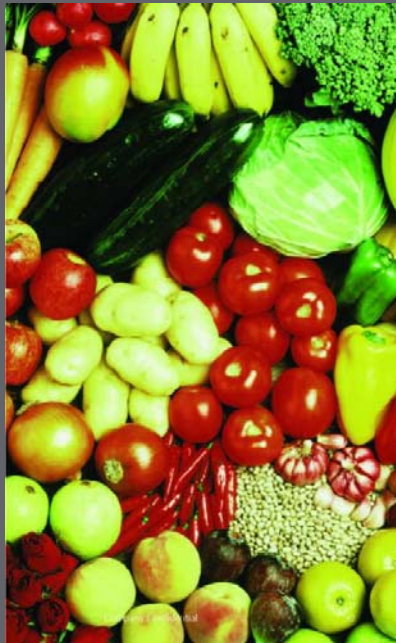
- Competing technologies:
  - Field walking and / or “Sentinels” (manual and late onset detection)
  - Satellite / aerial imaging (sporadic and very late onset detection)
  - Weather models (limited accuracy)
- Motivation:
  - Current sensing techniques are too late to effect a CP treatment
    - Prophylactic spraying used or non at all (notably for monocyclic diseases)
  - Early host / pathogen interaction sensing enables appropriate CP formulation cocktail to be delivered to prevent yield losses + wide area forecasting (including climate change related analysis of disease)
    - Does not require ad-hoc spraying – retain farm equipment scheduling
- Approach:
  - In field **Sentinel Sensors** linked to network (exploit cellular comms & IT)
  - Early adoption: *Sclerotinia sclerotiorum* (OSR, potatoes, carrots - UK)
  - Second generation: *Septoria tritici* (yield limiting disease for wheat – EU)
  - Role out: Rust (Brazil, USA) and other globally significant pathogens



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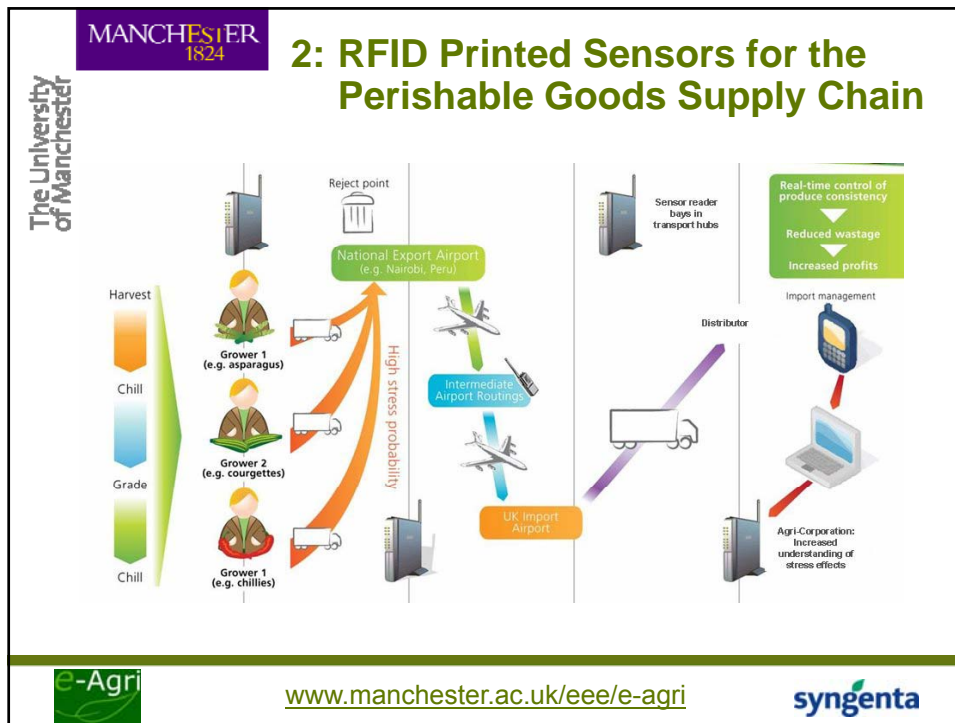




Photos courtesy of Syngenta

## 2: Real-time Supply Chain Management for Produce

- Initial business proposition suggested by growers
  - Need to reduce exposure to uncontrolled variability in supply chain
- 1 - Auction House
  - Perceived value of produce
- 2 - Supermarkets
  - Wastage: 21% losses from “farm to fork” equates to £20B in UK (2006)
  - Landfill costs
  - Carbon footprint (transport / inputs)
  - “Sell by” dates - supermarkets
- 3 - Internal Syngenta
  - Cuttings / Young Plants
  - Bio-line



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## 2: Implementing RFID-Sensors

- First generation technology
  - Get to market quickly using existing high cost RFID-sensors linked to new models to project forward produce shelf-life / remedial treatment
- Second generation technology
  - Geared funding from TSB with Syngenta, Xenia and Kingston Chemicals
  - Develop low cost, battery free, printable RFID-sensors for future mass deployment of first generation technology (disposable units)
- Co-research between EEE, Physics & Chemistry (UoM)
- Business model development
  - Assistance from 6 person "international project" by Business School
  - Quantify size of goal & value extraction mechanisms (Business Plan for farmer through to retailer)
  - Sanctioned project with Sustainable Consumption Institute to link retailer needs & e-commerce (sponsored at UoM by Tesco)

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### 3: Sub-soil Imaging for Accelerated Crop Breeding

Chemical plant research...

...translated to plant breeding

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## 3: Research aims for subsoil water & nutrient imaging

- Short to medium term targets
  - Widely deployable (low-cost & compliant) non-invasive imaging technology to isolate drought tolerant crops (maize and soybean)
  - Screening within glasshouse studies (semi controlled conditions)
  - Expansion into global field stations (variability - weather, soil, fauna)
- Longer term target
  - Optimised wide area irrigation, nitrification and burn-down management in commercial growing
  - High added value first (turfs => potatoes => bulk crops)
  - Broaden to other crop input traits (yield efficiency, salinity, disease...)
- Cross Disciplinary Research with Syngenta SBI (US) & Jealotts Hill (UK)
  - Electronic Engineering, Applied Maths (UoM)
  - Soil Science and Root Biology (Centre for Plant Integrative Biology, Nottingham)

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**... where we are going;  
The e-Agri Concept**

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**e-Agri: Evolving the UIC Model**



*e-Agri Research*

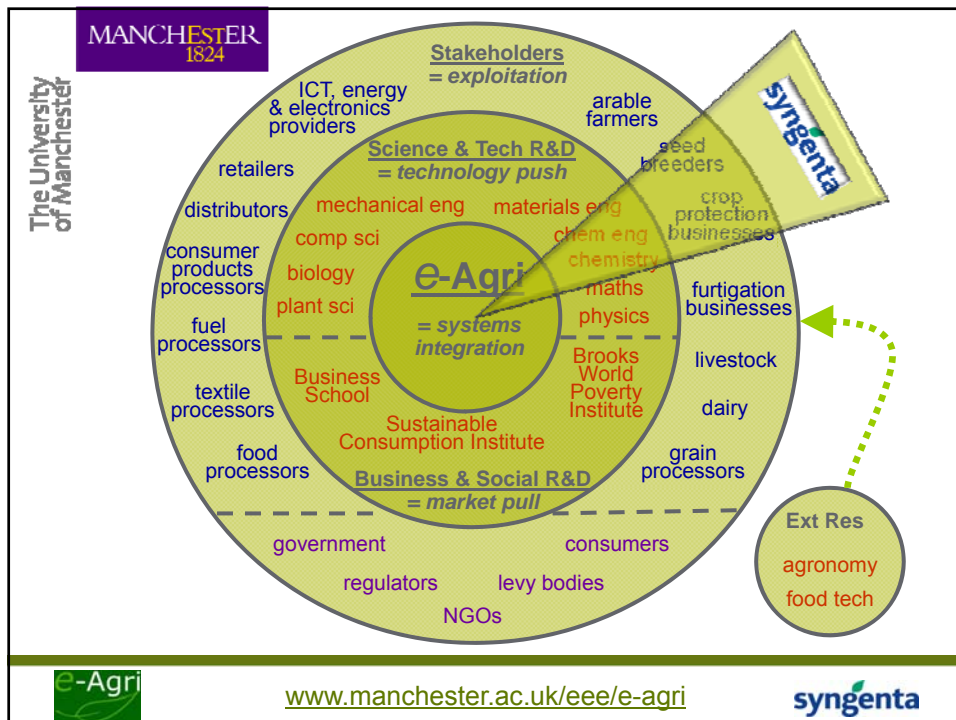
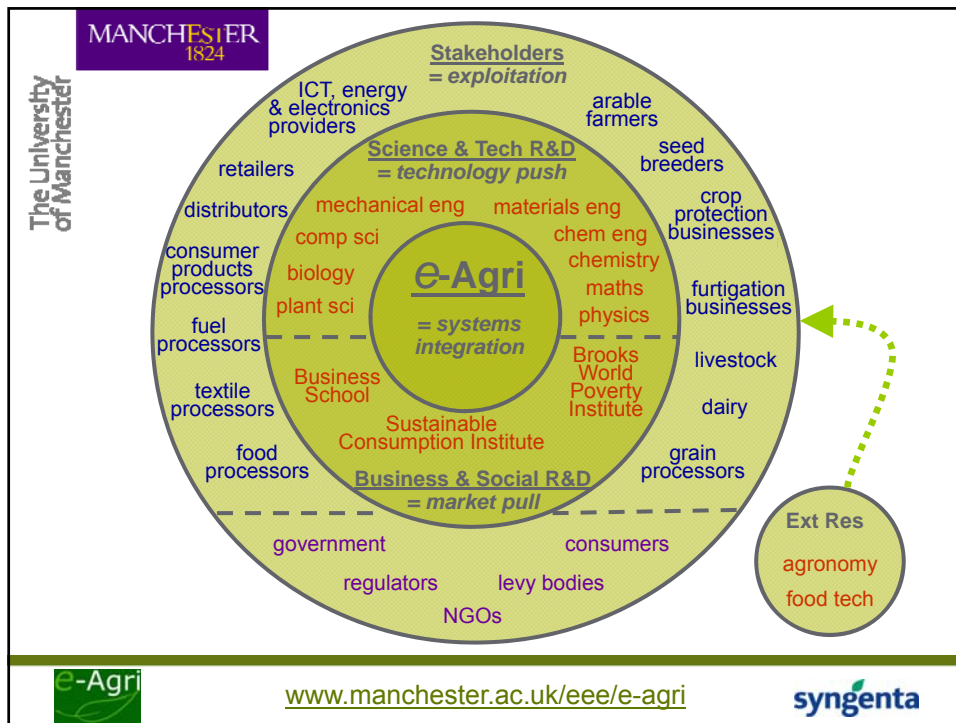
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*Innovative Business Models*

=

***Disruptive Technologies for  
Sustainable Agriculture  
& Food Security***

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## e-Agri Competitor (?) Analysis

- Future Partners: UK Government Funded Research Institutes
  - Rothamsted Research, Harpenden ([www.rothamsted.ac.uk](http://www.rothamsted.ac.uk))
  - John Innes Centre, Norwich ([www.jic.ac.uk](http://www.jic.ac.uk))
  - The Food & Environmental Research Agency, York ([www.fera.defra.gov.uk](http://www.fera.defra.gov.uk))
  - The Institute of Food Research, Norwich ([www.ifr.ac.uk](http://www.ifr.ac.uk))
  - National Non-Food Crop Centre, York ([www.nnfcc.co.uk](http://www.nnfcc.co.uk))
  - Horticulture Research Institute (HRI), Warwick ([www2.warwick.ac.uk/fac/sci/whri](http://www2.warwick.ac.uk/fac/sci/whri))
  - Environmental Informatics, Lancaster Environment Centre, Lancaster ([www.lec.lancs.ac.uk/cei](http://www.lec.lancs.ac.uk/cei))
    - Joint enterprise with NERC CEH ([www.ceh.ac.uk/sci\\_programmes/env\\_info.html](http://www.ceh.ac.uk/sci_programmes/env_info.html))
  - Institute of Grassland & Environmental Research (IGER), Aberystwyth ([www.aber.ac.uk/en/ibers](http://www.aber.ac.uk/en/ibers))
  - Scottish Crop Research Institute (SCRI), Dundee ([www.scri.ac.uk](http://www.scri.ac.uk))
  - Macaulay Land Use Research Institute, Aberdeen ([www.macaulay.ac.uk](http://www.macaulay.ac.uk))
  - Centre for Ecology & Hydrology, Edinburgh ([www.ceh.ac.uk](http://www.ceh.ac.uk))


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## What is so special about the UoM e-Agri Theme?

“Manchester’s e-Agri initiative is highly differentiated from other research institutions as its approach is to partner with agri-food businesses and associated academics from elsewhere and draw on internal engineering and physical science expertise to reflect these needs into what **future sensor technologies** may be developed to meet the forthcoming challenges.”

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## But we are now not alone!

- In 2010 the German government has given €9.7M to support CROP.SENSE.net ([www.cropsense.uni-bonn.de](http://www.cropsense.uni-bonn.de))
  - Based out of Bonn and Jülich Universities
  - Includes 9 Universities, 4 Research Institutes and 8 Companies (**Including BAYER Crop Science**)
  - Founded around 35 projects and two proxy crops (Barley and Sugar Beet). All research is pre-harvest. Almost all use **existing sensors**.
  - Bidding for a further €4.7M RDA funding (N.Rhine-Westphalia regional government) for a Phenotyping centre at Bonn
  - Currently a German national initiative only
- Two meetings have been held so far between e-Agri & CROP.SENSE.net
- **A good opportunity for UoM / UK leadership on in EU Network**
  - Long game UoM then becomes known in EU as partner-of-choice

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## UK & EU Support for e-Agri

- *“The agriculture industry needs to double its food production, using less water than today” \**
- *“The food crisis will bite more quickly than climate change” \**
- *“New technologies such as non-invasive sensors can be applied throughout the food chain” \**
- Qtr 4 2009, UK TSB ‘Sustainable Agriculture and Food’ programme - £90M (inc £40M BBSRC)
  - Beginning Qtr 1 2010, TSB £13M Crop Protection Competition
- April 2010, EU Joint Programme Announced on Agriculture, Food Security & Climate Change
- November 2010, UK Government Food Security Strategy to be released

Photos courtesy of Syngenta



\* Prof John Beddington, UK Government Chief Scientist, Guardian and Food Sci & Tec

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## The “3-i”s and e-Agri ...



### Intelligence

- Market intelligence from the Agri-Food community on the commercial, scientific and societal needs for the sector.


### Information

- New sensors and informatics technologies built upon an informed understanding of the emerging engineering & physical sciences.

### Imagination

- Creation of new **integrated business offers** founded upon existing core agri-products & competences alongside novel sensor devices & business models.

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