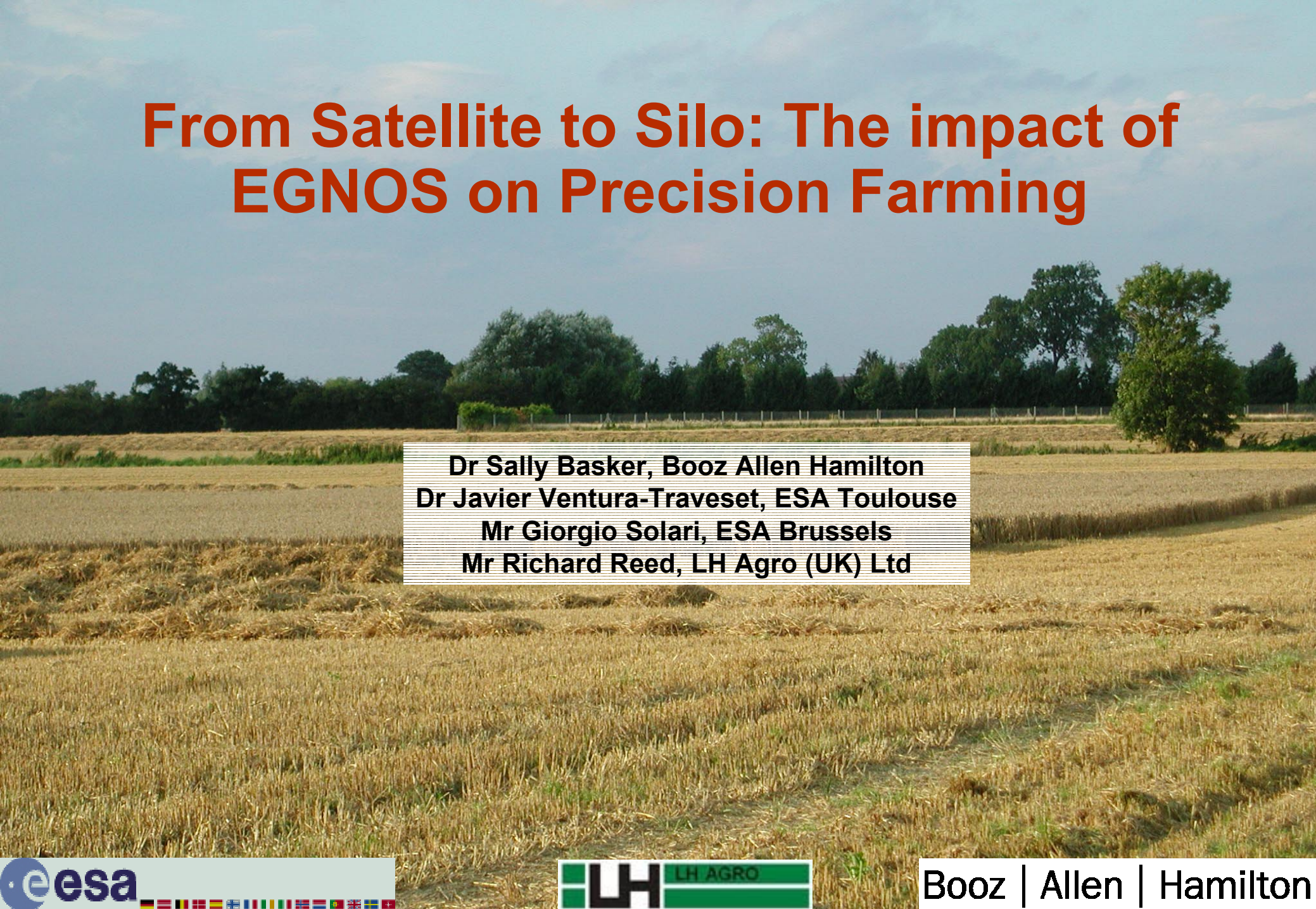
From Satellite to Silo: The impact of EGNOS on Precision Farming



Dr Sally Basker, Booz Allen Hamilton
Dr Javier Ventura-Traveset, ESA Toulouse
Mr Giorgio Solari, ESA Brussels
Mr Richard Reed, LH Agro (UK) Ltd

esa

LH AGRO

Booz | Allen | Hamilton

Contents

- Precision Farming
- EGNOS Demonstration
- Results
- Conclusions

Precision farming

- Why is precision farming important in the agriculture sector?
- Why use EGNOS for precision farming?

The European Commission's GALA study gives a good indication of the pressures faced by farmers

- There are increasing demands being placed on the modern farmer and his land for increased productivity to satisfy the World demand for food
- Problems in the agricultural sector (low prices and food chain issues) are at a high
- Farmers want to cut costs, and
- Chemicals are the highest cost input to a farm.

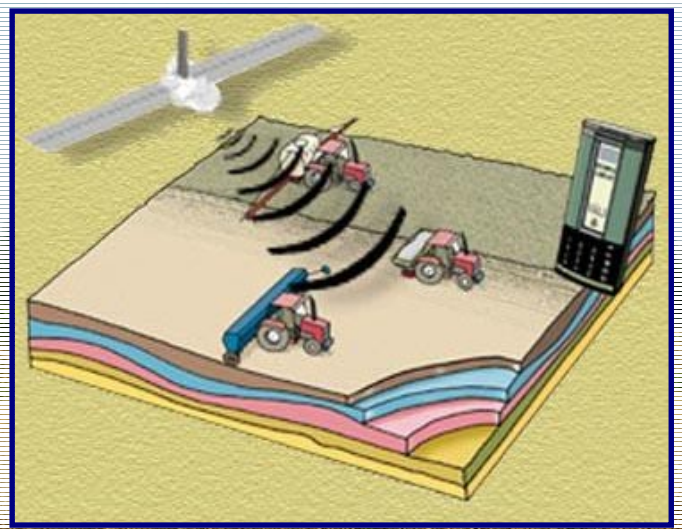
Source: Racal Tracs. Professional Market Applications Report. GALA-RACAL-DD004, Issue 2, 5 May 2000

Precision farming helps the farmer to manage arable variability and to optimise the yield / cost ratio

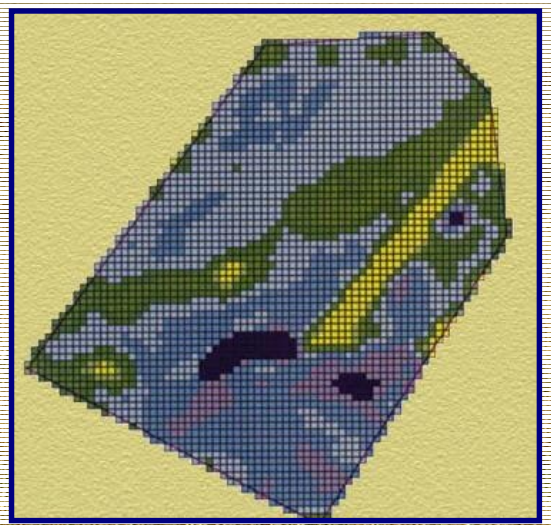
- Precision farming may be defined as "… the management of arable variability to improve the economic benefit and reduce environmental impact"[1]
- The farmer uses technology – variable rate application techniques together with accurate positioning - to monitor and assess performance at a local or farm level
- Custom prescription of farm chemicals are applied to small areas in a field
- The goal is not necessarily maximum yield, but may be to maximise financial advantage while operating within environmental constraints

Source: Blackmore S. Developing the principles of precision farming. Proceedings of Agrotech 99, Barretos, Brazil 15-19 November 1999

Put simply, it turns one 100-hectare field into 100 one-hectare fields to optimise the yield / cost ratio



Precision Farming



Application map

Yield Map

Precision farming can deliver significant cost savings to larger farms ...

- The European Commission's GALA study identifies the benefits of precision farming
  - cost savings of around 28€ per hectare per year, although farms need to be larger than 500 hectares to benefit
  - i.e. cost savings are in excess of 14k€ per year

Source: Racal Tracs. Professional Market Applications Report. GALA-RACAL-DD004, Issue 2, 5 May 2000

… but the high entry cost of precision farming is a barrier, and many farmers have cash-flow problems

- The cost of a combine harvester is about 265 k$ and an L-band DGPS system is around 4100 $ with an annual signal charge of 800 $, although a radio-beacon system is approximately 800 $
- Farmers with cash flow problems have stretched the replacement period from 2-3 years to 3-5 years
- During 1998-9, global sales of agricultural machinery were down by 43%, a trend that it set to continue

Farmers need cost-effective solutions including retro-fitting sensors … this is the motivation for using EGNOS

EGNOS will provide farmers with a new and cost-effective source of differential signals

- EGNOS has distinct benefits over the current radiobeacon or commercial systems
  - the EGNOS service covers all Europe wherever you can see the geostationary satellites, this is distinctly better than the coverage provided by the marine radiobeacons
  - the EGNOS service will be free of direct user charges, releasing users from paying commercial licence fees and
  - not needing a separate radio to receive differential corrections drives down the cost of the user equipment – hand-held receivers that can track EGNOS are now available and cost less than 300 €
- Cutting the cost of the positioning technology from, say, 4100 € with an annual signal charge of 800 € to less than 500 € should extend the economic and ecological benefits available from precision farming to farmers with smaller farms

Demonstration

- What did we do to demonstrate the benefits of EGNOS?

Booz Allen joined up with LH Agro(UK) Ltd and CBI Ltd for the purposes of this demonstration

- Booz Allen Hamilton
  - project manager
  - system overview
  - data processing
  - public relations support
- LH Agro (UK) Ltd
  - agriculture domain expert
  - technology integrator
  - good contacts with a friendly farmer
- CBI Ltd
  - loan of EGNOS-enabled Javad GPS receiver

We set well-defined aims, and waited for dry weather to harvest the wheat

- The aim of this demonstration was to use ESTB to geolocate the yield harvested from a field and to compare its effectiveness with marine radiobeacon systems
  - install an EGNOS receiver on a combine harvester
  - integrate EGNOS with the precision farming system
  - capture data during the harvesting that allows yield maps to be produced using both the ESTB and conventional systems
- The operations are critically dependent on the weather … the harvesting process needs dry crops

We ran the demo at St Ives near Cambridge in England on 21st and 22nd August 2001

The wheat harvested from this field gives the farmer an income of about 38 kEuro

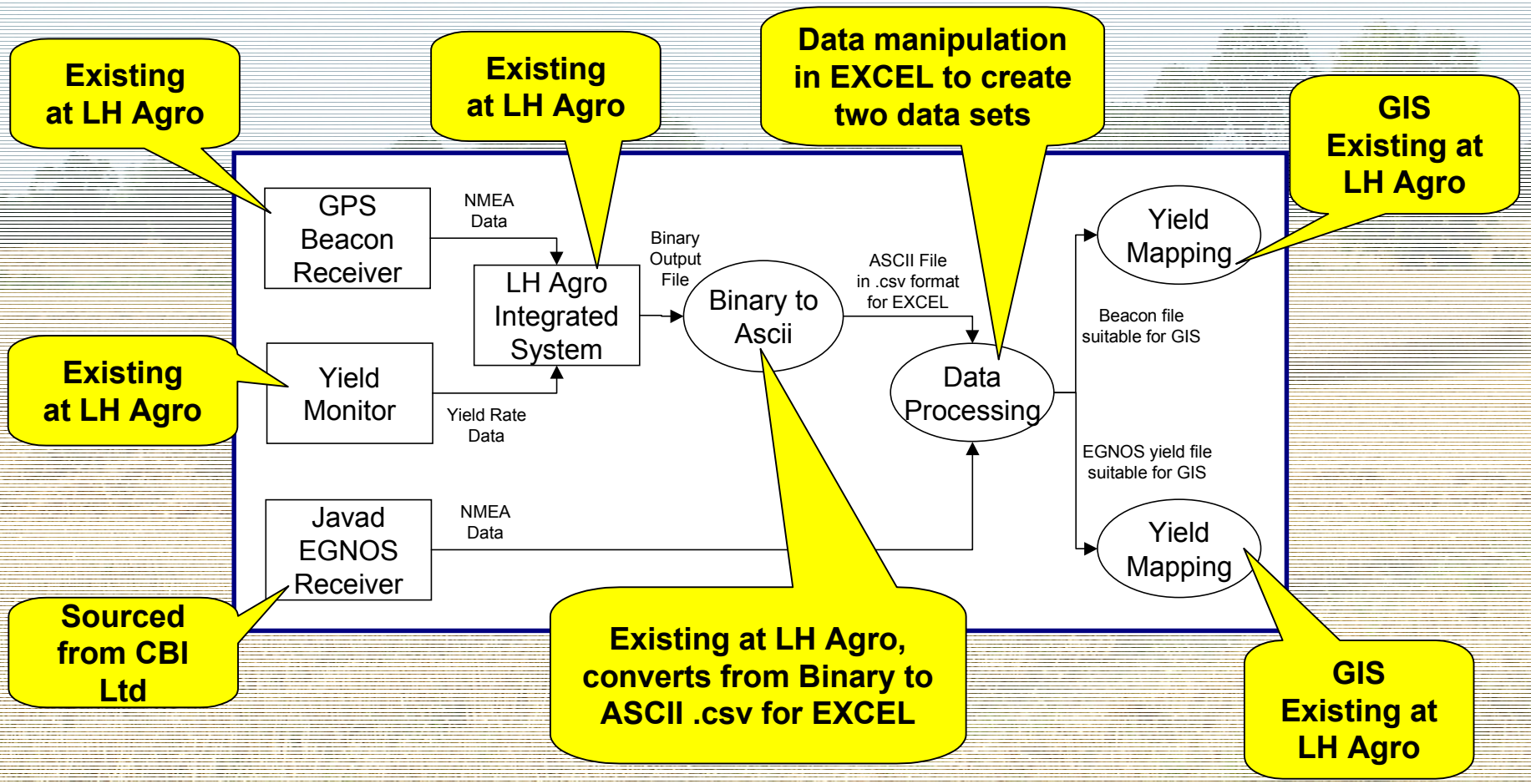
- 36.5 hectare field
- Yield is around 8 tonnes per hectare
- Selling price is about 130 Euro per tonne
- Field value is approximately 38000 Euro

but this is not profit, and we need to maximise the yield / cost ratio

Results

- How well did ESTB perform?

Our data processing scheme is tuned to existing hardware and software ...



… but the binary / ASCII conversion has provided a real challenge due to incompatible timestamps …

- We need to match the NMEA timestamps and those in the Ag Leader file (nominally GPS Time)
- GPS Time should be around 681696000
- What we have here is 998417596 - related to some form of PC Time
- There does not appear to be a logical or unique transformation

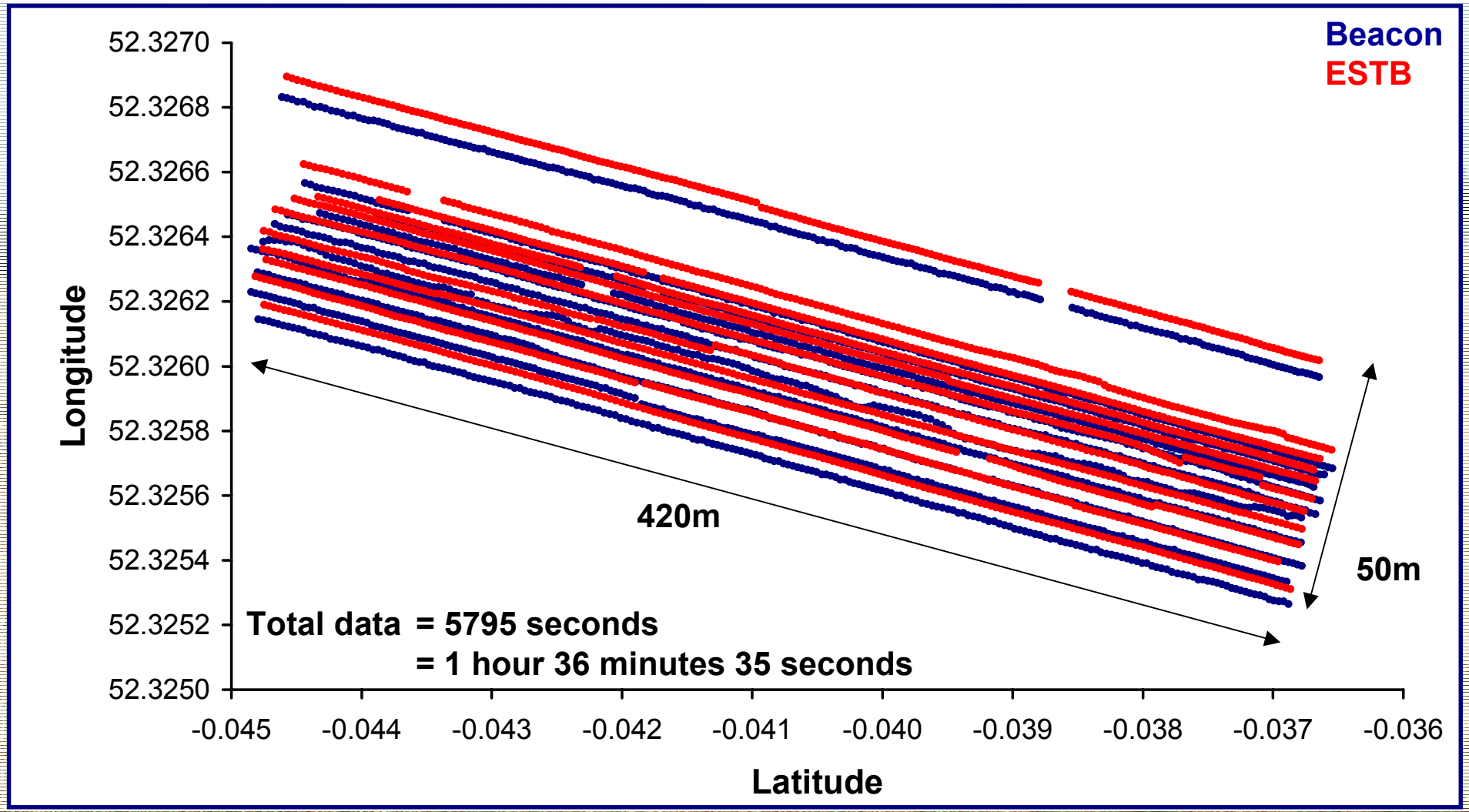
Long	Lat	Yield	Time
-0.036746	52.32552	14.54	998417596
-0.036781	52.325531	14.9	998417598
-0.036816	52.325539	14.97	998417600
-0.036853	52.325539	15.38	998417602
-0.036886	52.325535	15.69	998417604
-0.036926	52.325546	15.68	998417606

Binary to ASCII Export File

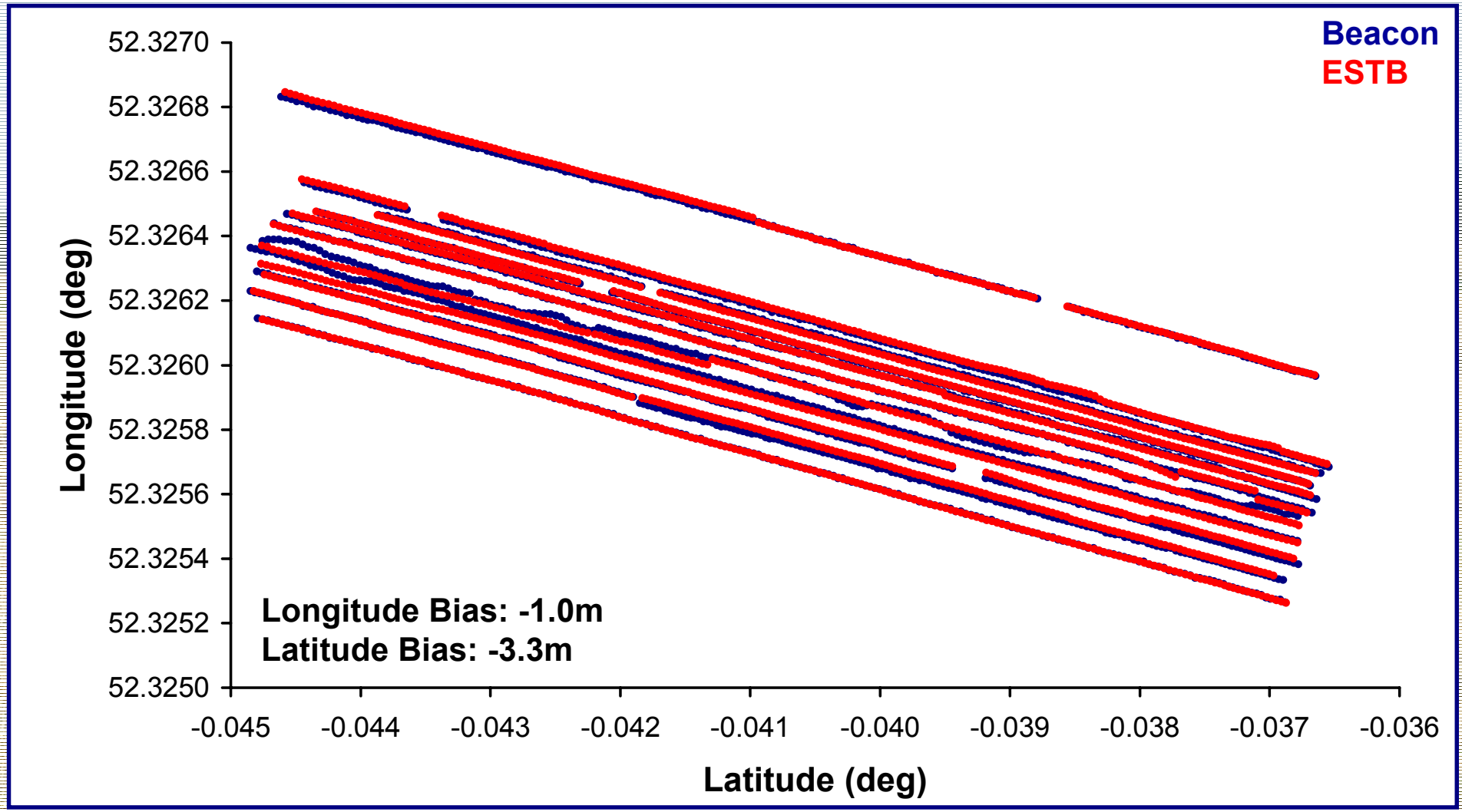
… and caused us to revisit our processing strategy

- The farmer drove the combine harvester in straight lines
- We determined the azimuth between successive points for both the beacon and ESTB data to identify the lines
- We then cross-correlated the beacon and ESTB data for eleven of the lines to find the “best fit” based on position differences as the criteria

Expressing the results graphically shows a small bias between the beacon and ESTB positions

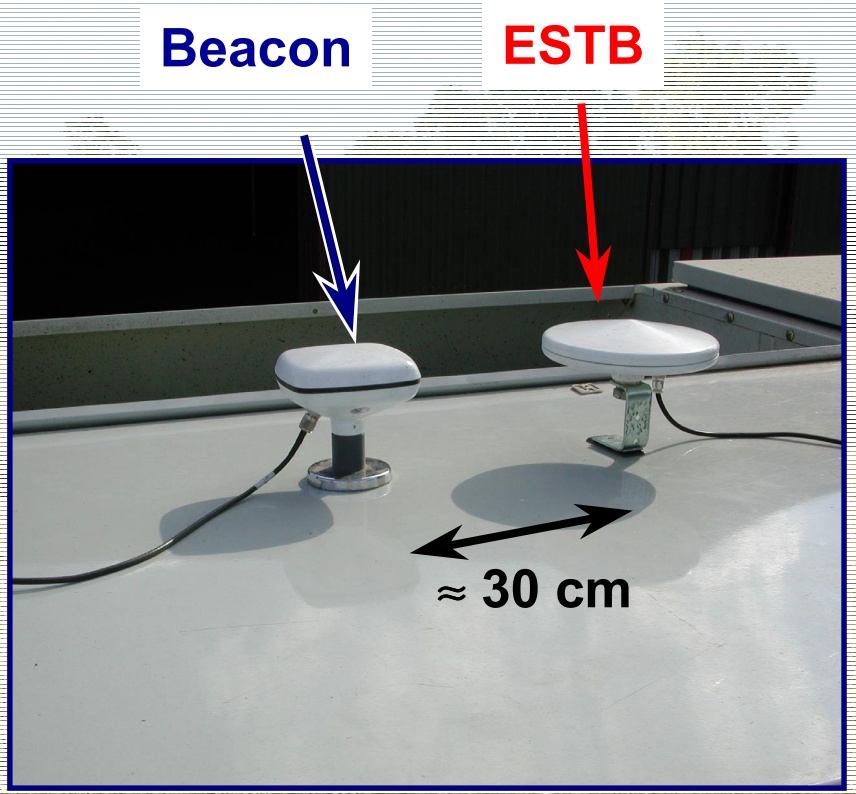


…and removing the bias leads to good agreement between the beacon and ESTB positions



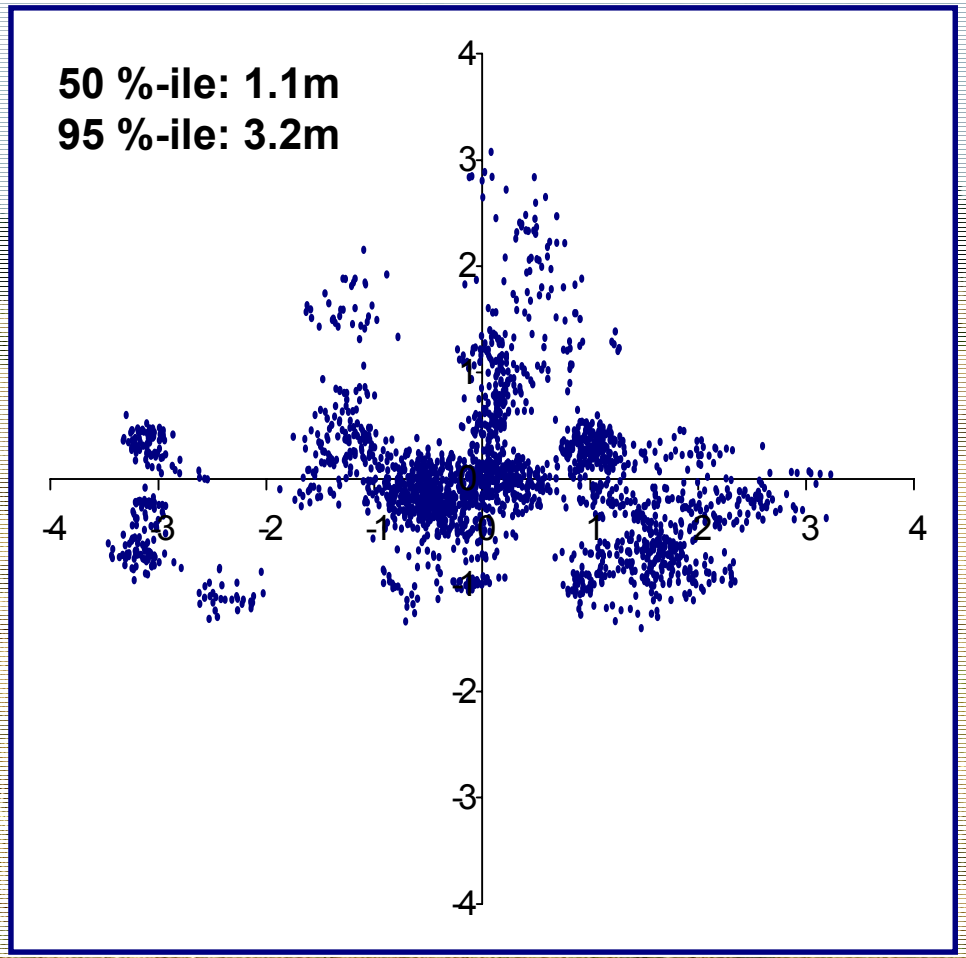
These can be justified as unmodelled antenna offsets and a reference frame misunderstanding

- The beacon and ESTB receivers used different antennas situated about 30cm apart on the centre-line of the combine harvester
- ESTB positions are known to have a zero-mean bias with respect to WGS84
- The UK beacons have been coordinated to better than 10cm
- We postulate that the remaining bias is due either to distance from the beacon or to a reference frame misunderstanding … TBD!

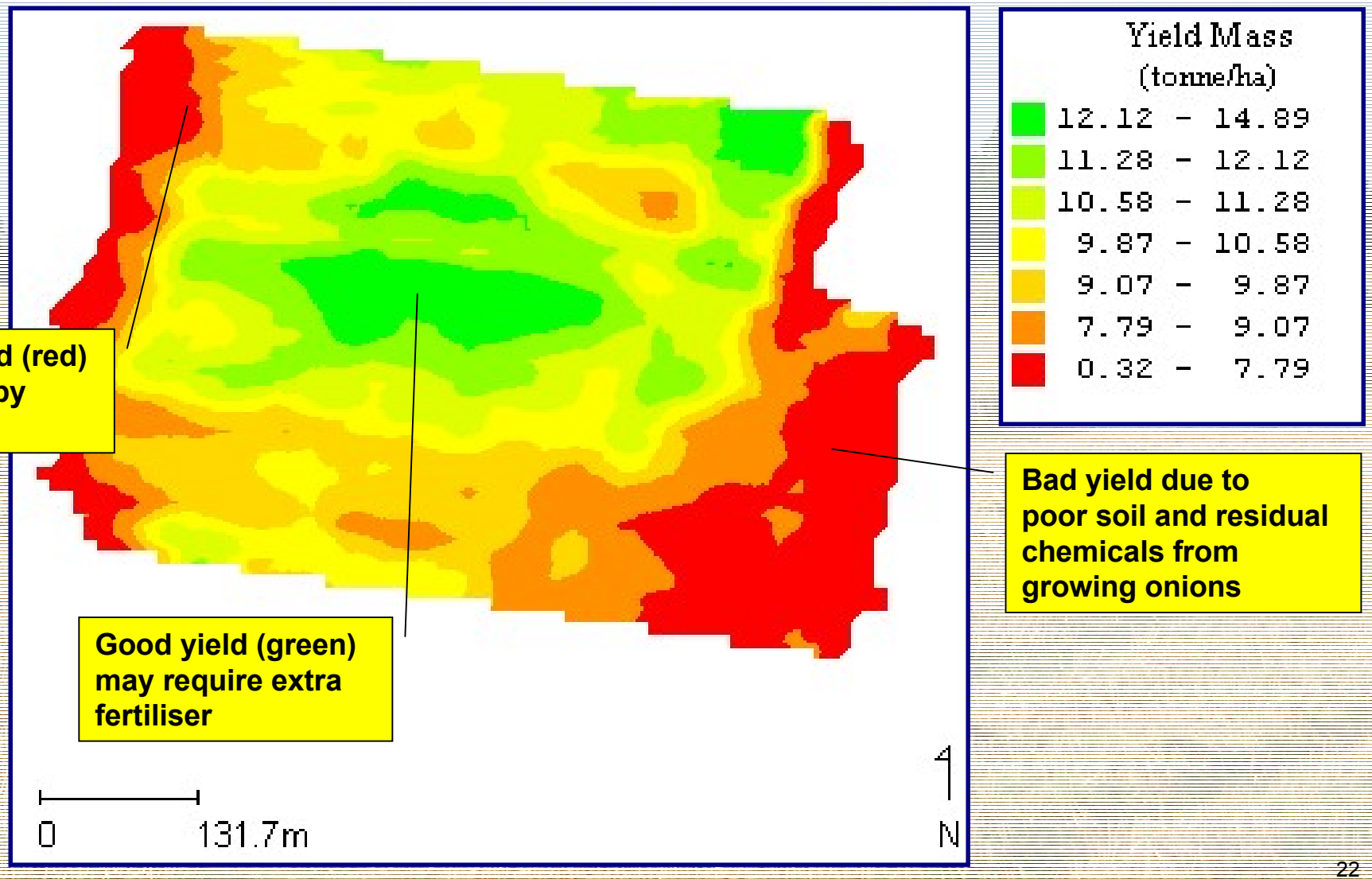


The beacon and ESTB solutions are in close agreement … and these results may be pessimistic

- There is a close agreement between the beacon and EGNOS solutions
- The cross-correlation was optimised by position difference involving some subjective decisions … these figures could well be pessimistic
- If we assume that both the EGNOS and beacon differential are 2m systems, then we should expect the difference to have a noise of around 3m



The resulting yield map - same for beacon and ESTB - shows areas with good and bad yield



Conclusions

- So what has EGNOS got to offer the precision farmer

We see EGNOS making a positive contribution, extending the benefits of precision farming

- EGNOS will provide a new cost-effective differential service option
  - today, we see that the ESTB provides horizontal positioning accuracies of around 2m - 3m
  - ongoing CPF optimisation should improve this to 1m - 2m
  - looking ahead, EGNOS should provide comparable or better performance
- It is our view that a combination of EGNOS together with advances in receiver technology will drive down the cost of the positioning element of precision farming
- This vision sees the benefits of precision farming technology being extended to more farmers with smaller farms, decreasing costs, enhancing economic competitiveness, and helping to improve the environment

esa

LH AGRO

Booz | Allen | Hamilton