OCR
Oxford Cambridge and RSA

Monday 3 June 2024 – Afternoon

Level 3 Cambridge Technical in Applied Science

05874 Unit 22: Global scientific information

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C345/2406

INSTRUCTIONS
- Do **not** send this Insert for marking. Keep it in the centre or recycle it.

INFORMATION
- This Insert contains the pre-release material that you have already seen.
- This document has **8** pages.

Pre-release research brief

You should carry out your own research on the themes given in this research brief. Your research will help you to prepare for your exam.

Your research is only for your own use. You must not bring your notes into the exam.

A clean copy of this research brief will be provided in the exam.

In your research you should consider the following themes:

- Categories of information holder
- Impacts on stakeholders
- Location of scientific information
- Quality management of scientific information
- Reasons for transmission of scientific information

The questions in Section A of the exam will require you to draw on the knowledge and understanding which you have gained while researching these themes.

Instructions:

Read the following two pages of information.

Carry out your own research on the themes given above.

Source A

Adapted from: GPS Correction Technology Lets Tractors Drive Themselves

NASA satellite navigation software has been adapted to allow the development of autonomous farm equipment [1]. As a result, farmers have enjoyed the benefits of using self-driving tractors and combine harvesters for more than a decade.

John Deere is an agricultural company producing highly-engineered farming equipment, supported by advanced technology. Company engineers at John Deere worked alongside scientists at NASA's Jet Propulsion Laboratory* (JPL) to research and develop GPS correction technology by adapting improved GPS receivers. This enabled capabilities such as 'yield mapping'. This is the use of GPS location data to determine how much of the harvest is coming from each part of the field. Measurements of mass flow, from the crop as it is harvested, and the moisture content of the soil in the field are recorded using sensors mounted on the combine harvesters. These measurements combined with the GPS data help farmers to determine which management practices, which crops and which hybrids (crop varieties) are the most productive. This knowledge improves the quality of decisions about where to allocate future resources.

A significant problem was identified during the process of research and development. It was found that uncorrected GPS can be inaccurate by up to 10 metres due to: (i) data errors, (ii) drift in the GPS satellites' internal clocks, and (iii) incorrect orbital parameters. John Deere engineers needed a system that could correct the signals with a high enough accuracy to allow GPS to guide the tractor or combine harvester with much greater precision.

NASA's JPL developed the first global tracking system for GPS satellites. They then worked on streaming satellite tracking data in real time, via the Internet. Government research and development funding from the Federal Aviation Administration (FAA) enabled them to develop the necessary software.

The result was the Real-Time GIPSY (RTG) software. GIPSY refers to the GNSS-Inferred Positioning System (GNSS stands for Global Navigation Satellite System). This led to RTG becoming one of NASA's most important contributions to modern society, due to the provision of highly accurate GPS navigation anywhere on the planet. Once NASA demonstrated real-time tracking on a global scale with real-time data processing, it represented a breakthrough capability for the use of GPS in agriculture.

In 2004, John Deere released the first StarFire receivers (mounted on the top of the tractor or combine harvester cab). These utilised NASA's global network of ground stations and incorporated JPL's software through a licensing agreement. The new system, accurate to within 10 cm, allowed John Deere to offer self-driving tractors and combine harvesters to its customers.

Typically, when a farmer criss-crosses a field pulling a seed drill, plough, or other equipment behind the tractor, the rows that are created overlap by about 10 percent. This means a significant portion of the field receives double the necessary seed, fertiliser and pesticide, and the job also takes more time. Eliminating this overlap cuts down on fuel costs, wear and tear on the machinery, and the time for which a farm has to pay a tractor operator.

The second-generation GPS StarFire receivers gave the iTEC-Pro capability. This allows a tractor to finish a row, lift the equipment it is pulling, turn around, and pick up exactly where it left off, all without input from the driver.

By 2015, 60–70 percent of the crop acreage in North America was being farmed using self-guidance systems, as was 30–50 percent of the farmland in Europe and South America, and more than 90 percent of Australian farmland.

[1] https://www.techbriefs.com/component/content/article/tb/pub/features/nasa-spinoff/28021

* JPL is federally funded by NASA. https://www.jpl.nasa.gov/

Source B

Adapted from: Economic and Environmental Impact Assessment of Tractor Guidance Technology

A. J. Ashworth, K. R. Lindsay, M. P. Popp, P. R. Owens Citations: 5

First published: 01 August 2018 [1]

Core Ideas

- Tractor guidance (TG) technology allows for spatially precise input applications (see note 1).
- A decision-support tool (see note 2) was developed to quantify environmental and economic impacts of TG.
- Greatest Carbon equivalent (CE) emission reductions and cost savings occurred with Cotton-Only scenario (see below for details of this scenario).
- TG was profitable for operations evaluated and led to reductions in CE emissions (see note 3).
- This tool may improve agricultural sustainability and enhance technology adoption.

Tractor guidance technology allows for more spatially precise input applications, which leads to efficiency gains. A decision-support tool, Tractor Guidance Analysis (TGA), was developed in the Department of Agricultural and Applied Economics, University of Arkansas. TGA made it possible to quantify CE emission reductions associated with this technology for three scenarios (500 ha each): (i) cotton (*Gossypium hirsutum L.*), (ii) soybean [*Glycine max (L.) Merr.*], and (iii) cotton and soybean mixed. CE emission reductions for cotton, soybean, and mixed enterprises were 27.5, 5.6, and 16.5 kg ha−1, with attendant increases in farm profitability ($68,700, $16,900, and, $42,900, respectively). Tractor guidance led to total farm CE emission reductions of 15.7, 3.5, and 9.6 tonnes for cotton, soybean, and mixed operations, respectively. These results highlight that CE reductions are (i) crop specific, (ii) scale dependent, and (iii) equipment and input-use specific. Consequently, TGA can improve agricultural sustainability by informing users of economic and environmental repercussions of tractor guidance and may thereby enhance technology adoption.

[1] https://doi.org/10.2134/ael2018.07.0038

Note 1 Input applications are the seeds, fertilisers, pesticides etc., that are applied with high precision across large areas.

Note 2 A decision-support tool is a custom-made computer program that processes input data into other, more useful, output data.

Note 3 Carbon equivalent is a method of making a fair comparison between different gases that have different impacts on global warming. It is the number of tonnes of CO_2 emissions with the same global warming potential as one tonne of another greenhouse gas.

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