A note on UHF tagging and ScotEID

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This note explains the rationale for inclusion of Ultra High Frequency (UHF) equipment alongside Low Frequency (LF) equipment in the evaluative field testing of electronic tagging of cattle in Scotland under Phase III of ScotEID the pilot project.

Introduction

1. Although electronic radio-frequency identification (RFID) is not the only form of animal identification available (Caja et al., 2004; Skujina et al., 2010), it has been promoted in recent years primarily due to the regulatory pursuit of improved livestock traceability systems in a number of countries (Golan et al., 2004; Carlberg, 2010; Hogewerf, 2011).

2. This reflects potential advantages of RFID in terms of speed and accuracy over more traditional manual and/or visual forms of identification such as conventional tags and barcodes (IDEA, 2001; Shanahan et al., 2009; Carne et al., 2009 & 2010), and the as-yet-unproven commercial practicalities of possible alternative technologies such as retinal scans, muzzle recognition or DNA testing (Barry et al., 2007; Allen et al., 2008; Gonzales et al., 2009).

3. However, RFID itself can take a number of forms and continues to evolve - as documented in a wide and increasing number of academic papers and commercial reports spanning disciplines such as electronic engineering, information systems, computer science, business strategy and economics (Ngai et al., 2008; Ruiz-Garcia et al., 2009). The pace of this continuing rapid development and its disparate reporting means that commonly-held perceptions of potential applications can perhaps easily become out-dated since the applicability and relevance of progress in one sector may not be recognised immediately in another.

4. This highlights the importance of retaining openness to different technical possibilities and of the need for independent, empirical field-testing of particular applications. This is the role that ScotEID has played with respect to working with industry in identifying preferred practical solutions for electronic tagging of livestock. To date, the emphasis has been on electronic tagging of sheep but attention is now switching to cattle.

Technical background

5. The basic elements of radio-frequency identification (RFID) and related wireless technologies have been known since at least the second world war, with the first commercial applications appearing in the 1950s and in agriculture in the 1970s (Rossing, 1999; Pugh, 2004; Landt, 2005). Since then, applications have developed apace and can now be found across many diverse sectors. For example, agriculture, construction, food, library services, logistics, pharmaceuticals and road pricing (Ngai et al., 2008; Ruiz-Garcia et al., 2009; Atzori et al, 2010).

6. Within this, although sharing much in common, specific RFID applications can vary with respect to technical and commercial details. Of these, an important one relates to the radio wave frequency that is used to communicate between a (typically static) reader and a (mobile) transponder.[1] Two commonly used categories are referred to as Low Frequency (LF) and Ultra High Frequency (UHF).

7. Different wavelengths have different electromagnetic properties that result in different performance characteristics and potential suitability to different applications. For example, all other things being equal, higher frequencies can travel (be read at) greater distances and with a greatly enhanced data rate than lower frequencies, but are more susceptible to interference (being absorbed or blocked) by other objects (Pugh, 2004; Lewis, 2004).

8. However, the magnitude and practical significance of these differences also depends on the design and deployment of a specific application. That is, the effect of intrinsic electromagnetic properties can be enhanced or reduced through the quality of manufacturing and manner of usage of equipment and through technical progress. For example, both the materials used and the method used to construct transponders as well as the size, orientation and retention of tag antennae can all affect performance.

9. As a result, not all applications using a given frequency will perform equally nor can performance differences between applications necessarily be inferred solely from differences in the frequencies deployed. Hence, for example, the performance variation noted previously by ScotEID[2] and by others (Deavours, 2005; Stewart et al., 2007; Wallace et al., 2008; Ryan et al., 2010).

[1] Other differences in the context of livestock identification applications may include, for example, whether transponders are internal (boluses, injectable chip) or external (ear, leg, tail tag), whether readers are hand-held or fixed and whether a transponder has its own energy source (active) or gets its energy solely from the reader (passive).

[2] See http://www.scoteid.com/, particularly the Phase I & II reports therein.

LF & UHF in agriculture

10. To date, agricultural RFID applications have been dominated by LF (125 – 135 khz) rather than UHF (850-900 mhz) examples. This may be due to a number of factors, including the relative maturity and thus familiarity and incumbent market share of LF technology compared to UHF. It may also stem from perceptions of UHF as being too expensive and/or unsuitable for agricultural conditions due to relatively poorer read rates in the presence of metal, water and dense material or objects (Artmann, 1999; Jansen & Eradus, 1999; Stanford et al., 2001; FCEC, 2009).

11. However, even if this was the case in the past, technical progress in the design, manufacture and use of UHF systems over the past decade suggests that such perceptions may now be misplaced. In particular, high-volume applications in other sectors have driven investment in R&D to both improve technical performance and lower the unit cost of UHF technology (Anon, 2006; Ng, 2008; McCarthy et al., 2009; Tang & Wang, 2011).

12. Moreover, prompted at least in part by regulatory pressure for enhanced traceability, agricultural-specific design improvements have also been explored (Ng et al., 2005; Leong et al., 2007; Sasloglou et al., 2009) and there have also been limited but generally favourable field trials. For example in New Zealand (Hartley, 2008; Sundermann & Pugh, 2008; Cooke et al., 2010; Hartley & Sundermann, 2010), the USA (Reinholz et al., 2006), Brazil and Taiwan.[3] Field trials are also starting in Canada[4] and – perhaps most notably – a UHF tag has been approved for use in the USA's traceability system.[5]

13. As well as suggesting that UHF applications are capable of operating as satisfactorily as LF in the presence of water, metal and other sources of interference or obstruction, reported findings also suggest potential advantages over LF. For example, UHF equipment is cheaper, is directional and is capable of accurately reading multiple tags at a much faster rate and greater range (see Annex A).

14. Technical possibilities reported in academic papers and claims made by commercial entities should always be viewed with a degree of caution (Hess, 2006; Barthel et al., 2009: p21.). Nevertheless, the existence of such reported findings is sufficient to challenge generic pre-conceptions about the scope for using UHF in cattle traceability given that – unlike for sheep - there still remains some flexibility regarding technical choices within the EU regulatory regime.

[3] See http://www.rfidjournal.com/article/view/4968
[4] See http://www.lis-alberta.com/brands/policy_electronic.aspx and http://www.manitobacooperator.ca/news/high-tech-ear-tags-to-be-put-to-the-test/1000531493/ plus http://www.eriginate.com/NewsEvents/DairyWhitePaper_v4.pdf
[5] See http://www.rfidjournal.com/article/view/7304 and http://www.richardbealblog.com/?p=4487

RFID promotion and adoption

15. Patterns of technical innovation and adoption reflect a combination of the technology-push of research and development (R&D) activities with the demand-pull exerted by the requirements of regulatory compliance and the continual search for productivity gains. However, having imposed regulatory requirements for enhanced livestock traceability, Government then faces a dilemma over the degree of further technical prescription to apply.

16. On the one hand, promoting a particular technical option may help to establish a degree of commonality across an industry through scale and network effects. Yet on the other hand, locking into a particular technology may stifle innovation and flexibility – a reason why economists often favour the setting of performance (i.e. what has to be achieved) rather than technical standards (i.e. how it is to be achieved: Gunningham et al., 1998; Swann, 2000; MacLeod et al., 2009).

17. Yet in either case, regulators and industry alike need evidence upon which to base informed decisions. That is, as with any technology, the suitability of RFID to a particular sector or to an individual firm within a sector will depend on a number of factors and different RFID solutions may be applicable under different situations.

18. Agriculture is not unique in this respect (Ching & Tai, 2009; Curtin et al., 2010; Ferrer et al., 2010) and considerations extend beyond technical characteristics of a particular RFID application to also encompass situational factors and governance arrangements (Fosgate et al., 2005; Reinholz et al., 2006; Bechini et al., 2008; Thakur & Hurburgh, 2009; Hossan & Quaddis, 2010; Shanahan et al., 2009; Voulodimos et al., 2010; Wasike et al., 2011).

19. For example, whilst an RFID application needs to be effective under commercial conditions over a sustained period of time, technically superior equipment may be more expensive and/or require significant (re)training or other adjustments to existing management systems. Equally, requirements for data access and sharing may necessitate adjustments to existing infrastructure and governance relationships between different parts of the supply-chain, something that can only be achieved with industry co-operation and wide-spread stakeholder and peer-group support.

20. The absence of independent, large-scale UHF field trials hinders both the evaluation of the relative technical merits of competing RFID options but also the development of workable solutions that exploit appropriate technical capabilities. ScotEID essentially seeks to fill this information gap.

The role of ScotEID

21. The ScotEID pilot exists to identify workable and affordable electronic tagging systems to comply with European regulations on livestock traceability. Although the primary focus during Phases I & II was on LF applications, ScotEID seeks to be technology-neutral in simply presenting empirical evidence of how competing applications perform under commercial conditions in Scotland. Consequently, given the positive UHF findings reported elsewhere, it would be remiss to not give some consideration to the potential for UHF since – unlike for sheep – there remains some regulatory flexibility over technological choices for cattle traceability.

22. Despite LF equipment being the main focus of testing during Phases I & II, some UHF testing was also conducted.[6] This has been supplemented more recently with further testing of different UHF tag types and investigation of different UHF readers is planned. As before, field-testing will be supplemented by separate laboratory testing[7] of tags to explore technical limitations and possible causes of poor performance. Importantly, ScotEID software is compatible with both LF & UHF equipment and the two can co-exist.

23. Whilst only preliminary, the ScotEID assessments are in-line with those reported elsewhere. For example, in general but with some variation across different configurations, UHF tag performance is not adversely affected by light rain and both the range and rate at which tags can be read are greater than for LF tags. Along with possible cost savings on readers and tags, this offers potential practical advantages in terms of the speed with which cattle can be processed without close handling or confinement. Moreover, UHF tags lend themselves more readily to securely holding cattle passport data (see Annex A). The masking effect of body tissue on read ranges will be investigated further.

24. As with LF equipment[8], it is likely that larger-scale testing of UHF equipment will reveal a host of hitherto unknown issues regarding both technical design and operational implementation aspects of UHF deployment under different conditions and different parts of the supply-chain. As such, more extensive test results may or may not favour UHF over LF; it is an empirical matter that can only be resolved through a comparative evaluation, and this is the rationale for including both in Phase III of the ScotEID pilot.

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[6] See http://www.scoteid.com/Public/Documents/Scottish%20EID%20Trials%202006.pdf
[7] To be commissioned separately by the Scottish Government
[8] e.g. the lack of standards *within* LF and the effort needed to integrate different hardware, software and management systems.

Annex A: Summary of preliminary ScotEID assessment of UHF and LF equipment

	UHF	**LF**
Transponder	Thin flexible flat printed circuit with antenna, bonded onto adhesive or plain backing material.	Chip and copper wire air coil antenna or copper wire and ferrite rod, encased in glass or plastic.
Coupling mechanism	Backscatter	Induction
Transponder cost	Less than £0.10	Approx £0.35
Tag incorporation & size	Moulded flat on/in to the tag. Larger.	Transponder inserted or moulded into tag. Smaller.
Information	96 bit unique identifier + 416 bit user data (or more dependent on manufacturer) *Can put ISO 11784 onto UHF chip for data consistency, but no global standard.*	64 bit allocated by ISO 11784, global standard. *Higher capacity LF tags available, but not under ISO standard.*
Capacity - general	At a minimum, unique identifier plus all information on BCMS passport bar code.	3 numeric country code + 12 numeric animal no. *Again limited by ISO standard (but also data speed).*
Data Integrity	Unique identifier cannot be replicated. Enhanced security.	Can be re-written or cloned.
Data transmission rate	Up to 150 reads per second with 512 bits. Anti-collision capability as standard.	Best achieved consistently is about 10 reads a second with 64 bits. No anti-collision capability as standard – upgrade will necessitate changing readers too and not backwards compatible.
Read distance	Several metres dependent on antennae format – e.g. using directional antennae can pick out individual, unconfined animal at some range.	About 60cm (non- directional) with fixed reader and confined animal. Handheld typically 15 – 30 cm (slightly directional) but transponder dependant.
Field Distortion / containment	Fully directional. Will not penetrate through solid objects (walls) and can be contained by wire mesh with hole size < 3.4cm. Body tissue masking can limit read range. Not affected by light rain.	Non directional. Distorted by electromagnetic interference and metal penning/crushes. Not affected by light or heavy rain.
Indicative reader cost (excluding installation/training)	Fixed £650 - £2000; Handheld probably £700+	Fixed £8000 - £15,000+ Handheld £500 - £1,200
Conflicts	The technologies do not conflict with each other. Readers can work simultaneously in the same premises without interference.	

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