Initial UHF testing under ScotEID

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Introduction

1. An earlier ScotEID report[1] presented the rationale for exploring the potential of Ultra High Frequency (UHF) technology for cattle identification in Scotland. Specifically, improvements to technical performance and unit costs of UHF systems offer some interesting possibilities – but these need to be tested under commercial conditions. This short report provides a summary of work undertaken to-date to progress such testing within ScotEID.[2]

Equipment selected

2. RFID equipment is available commercially from a variety of manufactures and resellers, although in some cases identical equipment is sold under different companies' badges. However, whilst many different UHF transponders[3] and UHF readers are available[4], not all are suitable for livestock applications. For example, transponders (and thus tags) may be too large to attach to ears and readers may be too vulnerable to a harsh operating environment. Indeed, the relative novelty of UHF livestock applications limits the choice of tags somewhat and the physical size available on the tag limits the choice of available transponders.

3. In selecting UHF tags and readers for initial testing, ScotEID staff considered the availability of equipment, technical specification, size of transponder in relation to cattle tag, ease of installation/use and price. Choices were informed by prior experience with testing and using UHF and LF equipment and, where appropriate, external UHF reference material.[5] This resulted in ten different tags being selected, along with eight different types of readers.

4. Of the ten tags, eight are available commercially and the remaining two were constructed by ScotEID staff as variants on some of the eight. All ten are "far-field" tags using a back-scatter signal intended to be read at a distance of metres rather than centimetres.[6] All are "passive", activated by energy

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[1] See http://www.scoteid.com/Public/Documents/UHF_note.pdf

[2] Separately, mirroring previous arrangements for LF technology, the Scottish Government (SG) has also commissioned independent laboratory based testing of UHF equipment, in this case to be undertaken by the Scottish Agricultural College (SAC) and Strathclyde University. Results of this research are expected to be forthcoming.

[3] The combination of a microchip and an antenna also referred to as an inlay, which is then encased in (e.g.) a plastic tag.

[4] For example, see http://www.gaorfid.com/index.php?main_page=index&cPath=87 and http://www.gaorfid.com/index.php?main_page=index&cPath=134

[5] For example, see http://www.mifare-card.com/download/ODINBenchmark.pdf, and http://www.rfidjournal.net/Alliance_Lab_Report_intro.pdf

[6] A UHF tag used for pig identification in Denmark was considered but discounted on the basis that it is a "near field" and thus has a read range of less than 1m. It also lacks the capacity to store cattle passport data.

from the reader rather than an on-tag battery. The tags vary in size due primarily to variation in the size of transponder antennae. In some cases, suppliers have designed tags to take existing transponders; in others they have selected a transponder to fit a more traditional "flag" tag design [7].

5. The eight types of reader currently in use are:

ALIEN ALR 8800 (4 external antennae)[8]
CAEN R4300P Ion (4 external antennae)[9]
SIRIT 510 (4 external antennae)[10]
SIRIT 610 (8 external antennae)[11]
DEISTER UDL 510 (2 internal antennae)[12]
DEISTER UDL 150 (1 external antenna)[13]
MARKTRACE Handhelds (1 internal antenna)[14]
ICEKEY Handheld (1 internal antenna)[15]

Of these, the first six are fixed readers (most likely to be used at marts and abattoirs) whilst the last two are handheld readers (likely to be used on-farm, or to supplement fixed readers at marts and abattoirs). All eight operate on the European Standard for UHF frequencies (866-968 MHz), but some can also operate on the American standard (902 – 928 MHz). External antennae offer the possibility for bespoke positioning, plus swapping for antennae of different gain and beamwidth (i.e. directed signal strength and area illuminated). It is worth pointing out here that the costs of a "fixed reader" + antennae are similar to the cost of many UHF handheld. Interestingly, unlike LF, the prices of fixed and handheld readers are similarly low – meaning that both may be affordable at the farm-level.

Equipment testing

6. To-date, equipment testing has been largely restricted to controlled rather than commercial conditions in order to compare tags and readers on a like-for-like basis, primarily to establish reading distances, different reader antennae beam patterns and different types of transponder antennae being used.[16] Specifically, testing was conducted in August 2011 and February – March 2012 by ScotEID staff in the open away from metals and reflective objects. The background noise levels were measured as being less than 85dBm at the operating frequencies of the readers. Tags were moved progressively closer (rather than progressively further) from a reader until they registered, with this

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[7] For types of design being tested, see http://www.alientechnology.com/tags/index.php, http://www.impinj.com/Monza_5_RFID_Tag_Chips.aspx and http://www.upmrfid.com/rfid/upm_uhf-rfid-products
[8] See http://www.alientechnology.com/readers/alr8800.php
[9] See http://www.caenrfid.it/rfid/syproduct.php?fam=mread&mod=R4300PION
[10] See http://www.sirit.com/Product_Spec_Sheets/in510.pdf
[11] See http://www.sirit.com/Product_Spec_Sheets/in610.pdf
[12] See http://www.integer-solutions.com/RFID/passiveRFID.html
[13] See http://www.integer-solutions.com/RFID/passiveRFID.html
[14] See http://www.marktrace.com/en/product-detail-50.html
[15] See http://www.tertiumtechnology.com/icekey_en.php
[16] Commercial testing under more variable field conditions will proceed in due course.

being repeated for six different orientations of the tag relative to the reader (see Appendix A). Distance was measured using a laser rangefinder, reader output power was measured using an 800 MHz-1000 GHz SWR / Power Meter, and spectral analysis and field strength were checked by a WI-Spy 900x spectrum analyser and Chanalyser Pro software.[17]

7. Tags varied somewhat in their performance even with a given reader (see Appendix B), with (for example) maximum read distances[18] ranging from around 1.5m to over 6m and minimum read differences ranging from less than 0.3m to around 3.8m for different tags with the Diester UDL 510. Maximum and minimum distances were affected by tag orientation, but to different degrees for different tag designs (see Appendix B). Varying the reader frequency, power and antennae also influenced read distances (see Appendix C), but far less so than the choice of tag antenna and the tag design. This suggests that the main technical challenge lies in selecting appropriate transponders (i.e. chip & antennae combinations) and matching them to a suitable tag design that accounts for the effect of enclosing transponders in plastic.[19].

<u>Compatibility with ScotEID software</u>

8. ScotEID software has been developed and continually updated as system requirements have evolved and different items of equipment have been deployed. For example, different LF readers installed previously for sheep identification have had different control commands and data output characteristics ranging from simple ASCII to more complex outputs and each requiring bespoke modifications to the ScotEID Java application for data transfer. The same issue arises with UHF readers, but is no more difficult to address than the differences between LF readers and has been integrated into the Java application for the selection of UHF readers tested so far.

9. Separately, UHF tags can hold more information than LF tags and transfer data at a far faster data rate. However, again, the existing ScotEID software can cope with such additional data volumes and transfer speeds. For example, the database already contains species information and the leading 64 bits are more than sufficient to identify the animal using WYSIWYG so there's no immediate need to change from the format that is being used to send EID reads from sheep (the first 64 bits are identical to the ISO11784 standard). Possibilities for yet further extensions to data transfer are under consideration, but not yet implemented.

<u>Tag data capacities</u>

10. UHF readers can write as well as read to tags, offering the possibility of cattle passport data – including movement histories but also, for example, medical treatments – being stored on ear tags. However, this requires not only some consideration of what data should be included but also of how they should be encoded.

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[17] http://www.metageek.net/products/wi-spy/

[18] Ideally, the differences between maximum and minimum read distances would be relatively small, giving good performance in all directions (i.e. an isotrophic radiation pattern), but this is difficult to achieve.

[19] Testing transponders with and without their plastic enclosures, and in different plastic enclosures, revealed significant variation in performance.

11. Data blocks on a tag can be set to read only, write once, or read&write. Each tag has a unique "TID" (tag identifier) specifying the manufacturer, tag type and the tag's own unique number. This TID is burned (irrevocably) into the chip at time of manufacture and occupies a read-only data block usually 64 bits in size.

12. All tags also have an "EPC" (electronic product code) data block, typically occupying 96 bits. This is where the ScotEID software normally reads from and writes to, and is where the Animal Number, Date of Birth, Breed and sex are stored, plus a simple flag to confirm that it is a BCMS record. The proposed data structure developed by ScotEID is shown in the Appendix D. The first 64 bits of the 96 bit EPC area are identical to ISO1784 numbering and are write-once, for security (and in addition to the chip manufacturers write-once to TID).

13. Beyond the TID and EPC areas, UHF tags also have a user memory area. For a typical 512 bit UHF chip, 160 bits are usually occupied by the TID and EPC (i.e. 64 + 96), leaving 352 bits for the user. Additional user memory is available on many UHF chipsets as an option. Movement and medicine histories could be written to the user memory area, and all passport data should fit into the available space. Indeed, although further consideration of options is required, ScotEID systems already in place have the capability to pass barcode scan paper BCMS passports and write the data to a UHF tag using the existing UHF readers for this purpose.

<u>Stakeholder involvement</u>

14. In addition to on-going interaction with stakeholders through the ScotEID information centre, website and blog, four meetings have been held with representatives from across the industry and government to discuss UHF specifically. These included meetings at both the Winter Fair and at the Balbuthie Scottish beef cattle event, plus two other meetings on less prominent occasions.

15. At each meeting, ScotEID staff presented the case for evaluating UHF technology, offered a short demonstration of some UHF equipment and outlined technical details requiring further research. This was followed by stakeholder discussions of the pros and cons of UHF and of the practical issues to be explored from both commercial and government perspectives.

16. In general, despite some concerns over possible confusion arising from having different technologies for sheep and cattle, stakeholders saw potential advantages of using UHF for cattle and were supportive of ScotEID research into the practicalities of UHF applications. In particular, beyond the generic advantages of real-time reporting, stakeholders were interested in the potential for UHF tags to hold cattle passport information and for longer-range reading to reduce animal handling. There was also interest in developing hybrid LF/UHF tags.[21] Depending on results, initial small-scale trials should be expanded into larger-scale (phased) trials with continued development and evidence gathering to feed into the European Commission.

17. Indeed the importance of continued joint-working and clear communication was stressed repeatedly, both in terms of involving Scottish stakeholders but also in terms of raising awareness

[21] And some good progress has been made in this regard.

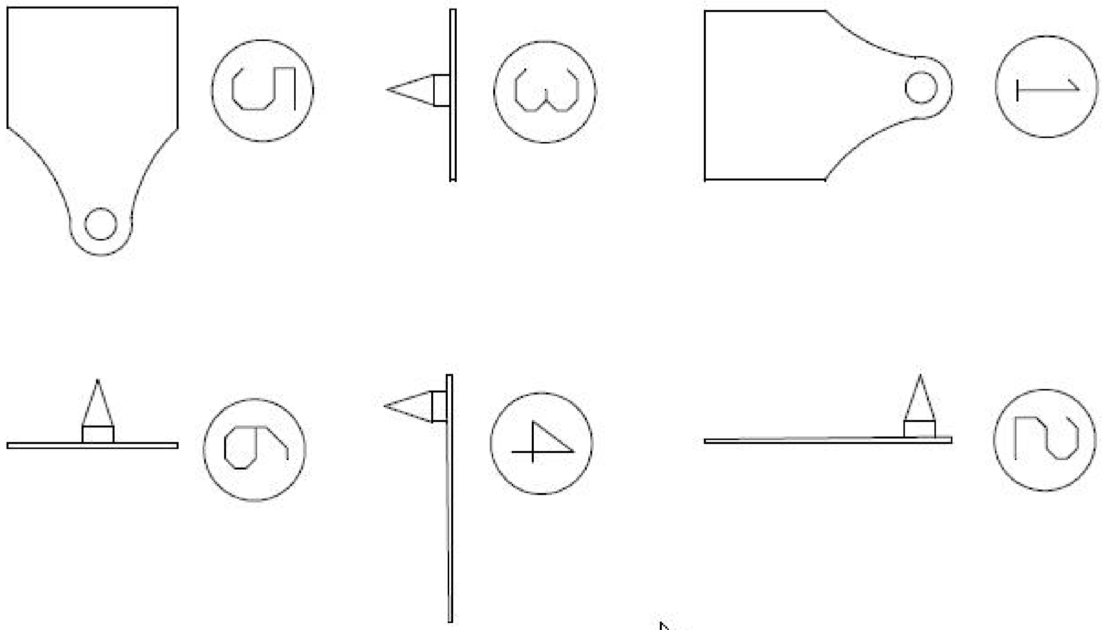
amongst UK and EU counterparts of Scottish work and concerns. Hence, for example, there was support for a Joint Scottish Industry/Government Working Group to continue looking at bovine EID systems best suited to Scotland but also continued industry and government engagement with counterparts and technical groups across the UK and Europe to ensure Scottish views and results are considered in national and EU level discussions.

Summary

18. Reflecting interest in the possibilities offered by UHF technology for cattle identification, ScotEID has undertaken some initial testing of UHF equipment, has continued to develop its software systems and has continued to engage with industry and government stakeholders to ensure practical relevance of its work.

19. The importance of transponder design and matching it to an appropriate tag design has been identified as a key technical challenge. The next stage will entail field-testing of tags and readers under commercial conditions. Results of this will be reported in due course.

Appendix A: Different tag orientations relative to reader



Appendix B: Variation in reading distances (m) with tag design and orientation

		Tag orientation relative to reader (see Appendix A)					
Tag Test Number	Size (mm)	1	2	3	4	5	6
1	60 x 23	3.35	1.3	3.51	1.34	2.88	3.57
2	25 x 63	4.16	1.16	4.26	1.44	4.38	4.28
3	55 x 16	6.25	1.44	5.92	1.51	5.98	4.75
4	45 x 45	5.41	3.55	1.9	2.54	4.05	1.77
5	45 x 22	1.53	0.33	0.86	0.28	1.24	1.27
6	45 x 22	3.72	0.69	2.73	0.97	1.99	2.2
7	50 x 50	6.35	3.16	3.57	3.86	5.82	4.68
8	50 x 50	4.72	2.99	2.96	2.88	4.16	3.51
9	50 x 30	4.09	3.86	3.39	3.3	3.82	3.41
10	50 x 30	1.95	0.85	1.26	0.66	1.84	1.92

Note: Deister UDL 510 reader used, as supplied and unmodified. Frequency of 866 Mhz, power 2 watts ERP.

Appendix C: Effect on read distances of varying reader antennae orientation and gain.

The following Figures illustrate the effect of changing the orientation and gain of reader antennae on read distances. Seven different tag types were used in this test, with the number of different tags read at a given distance indicated by the colour-coding.

Figure C1: Antennae orientation ↑, 11dBi gain

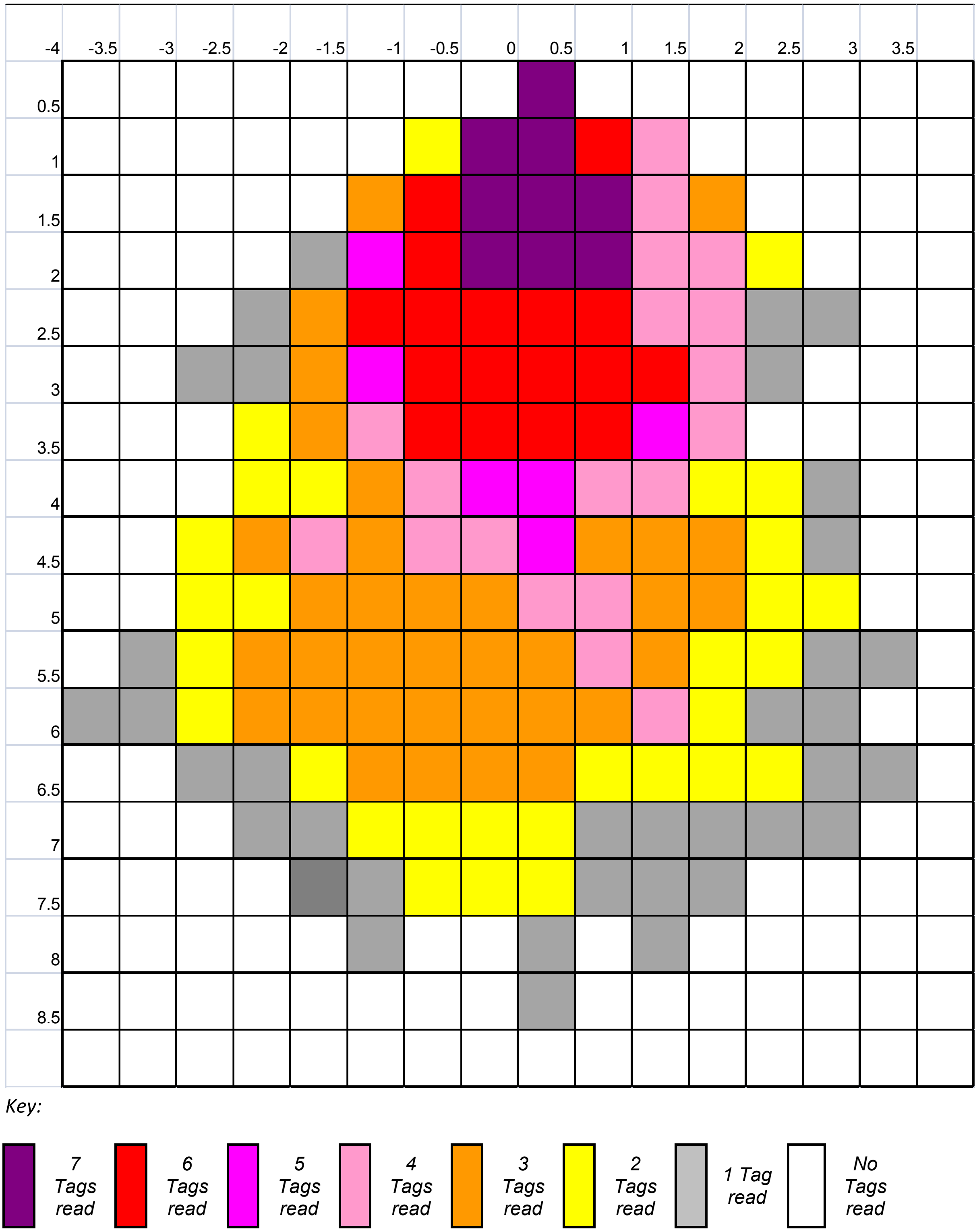


Figure C2: Antennae orientation →, 11dBi gain

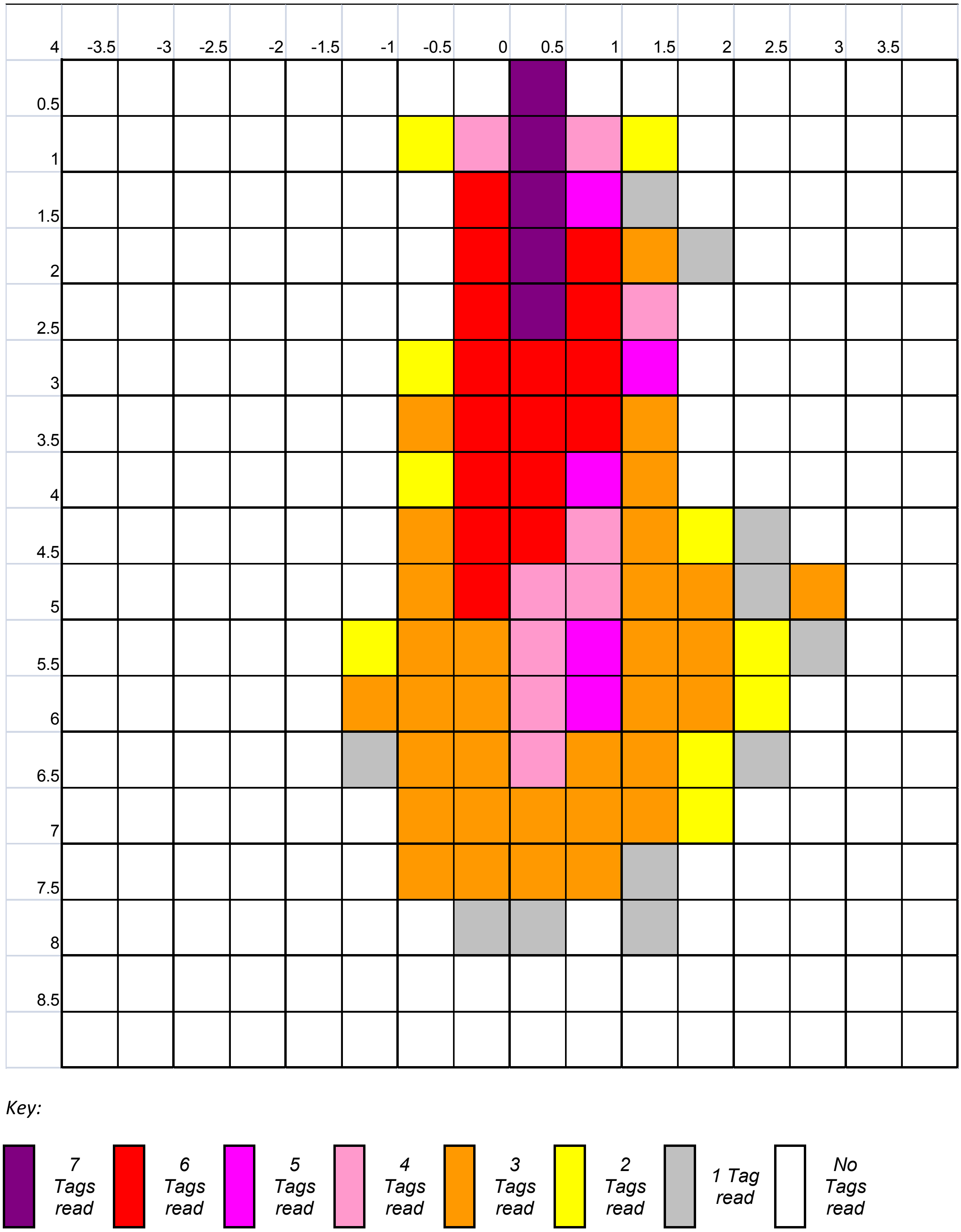


Figure C3: Antennae orientation ↑, 10dBi gain

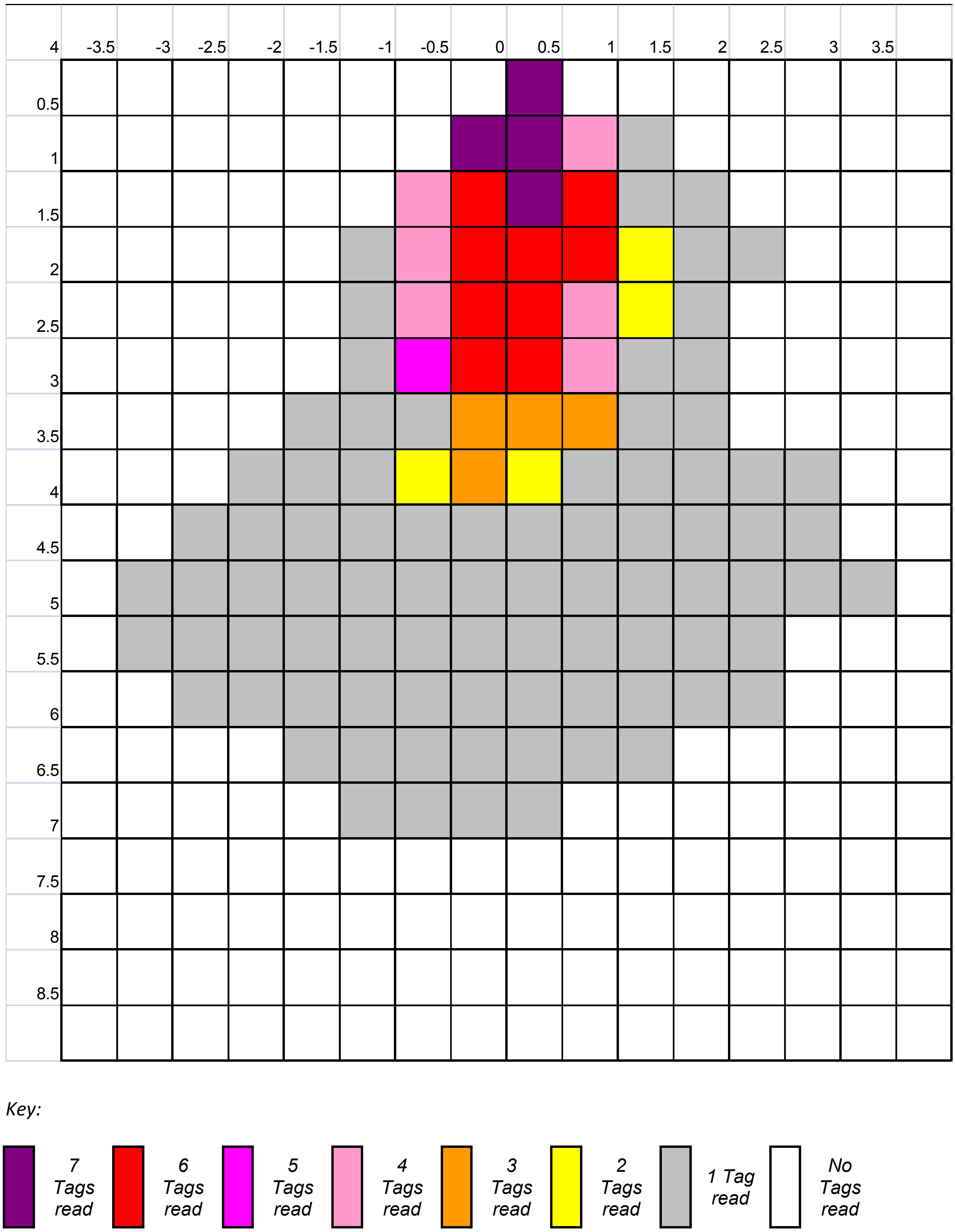


Figure C4: Antennae orientation →, 10dBi gain

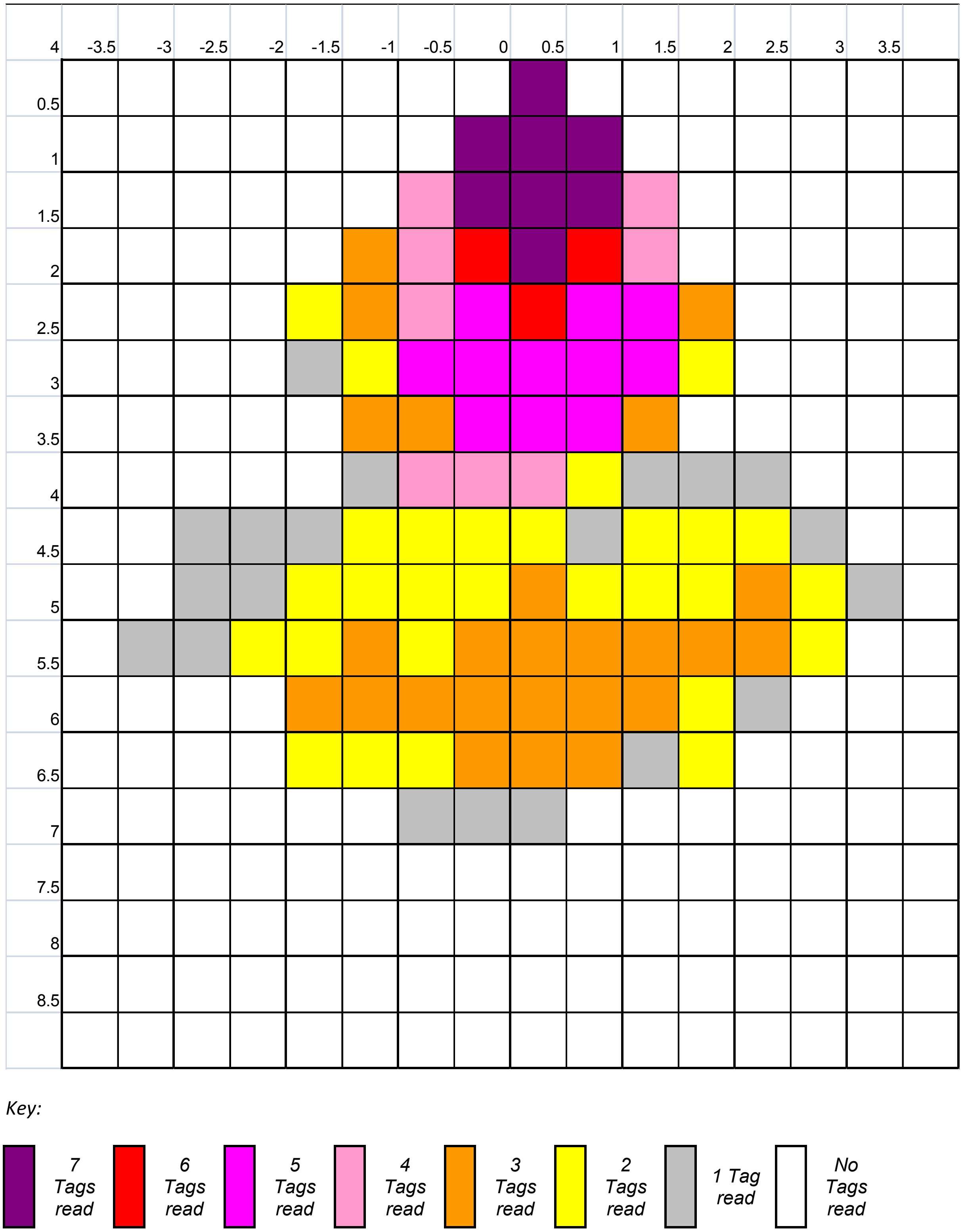


Figure C5: Antennae orientation ↑, 8dBi gain

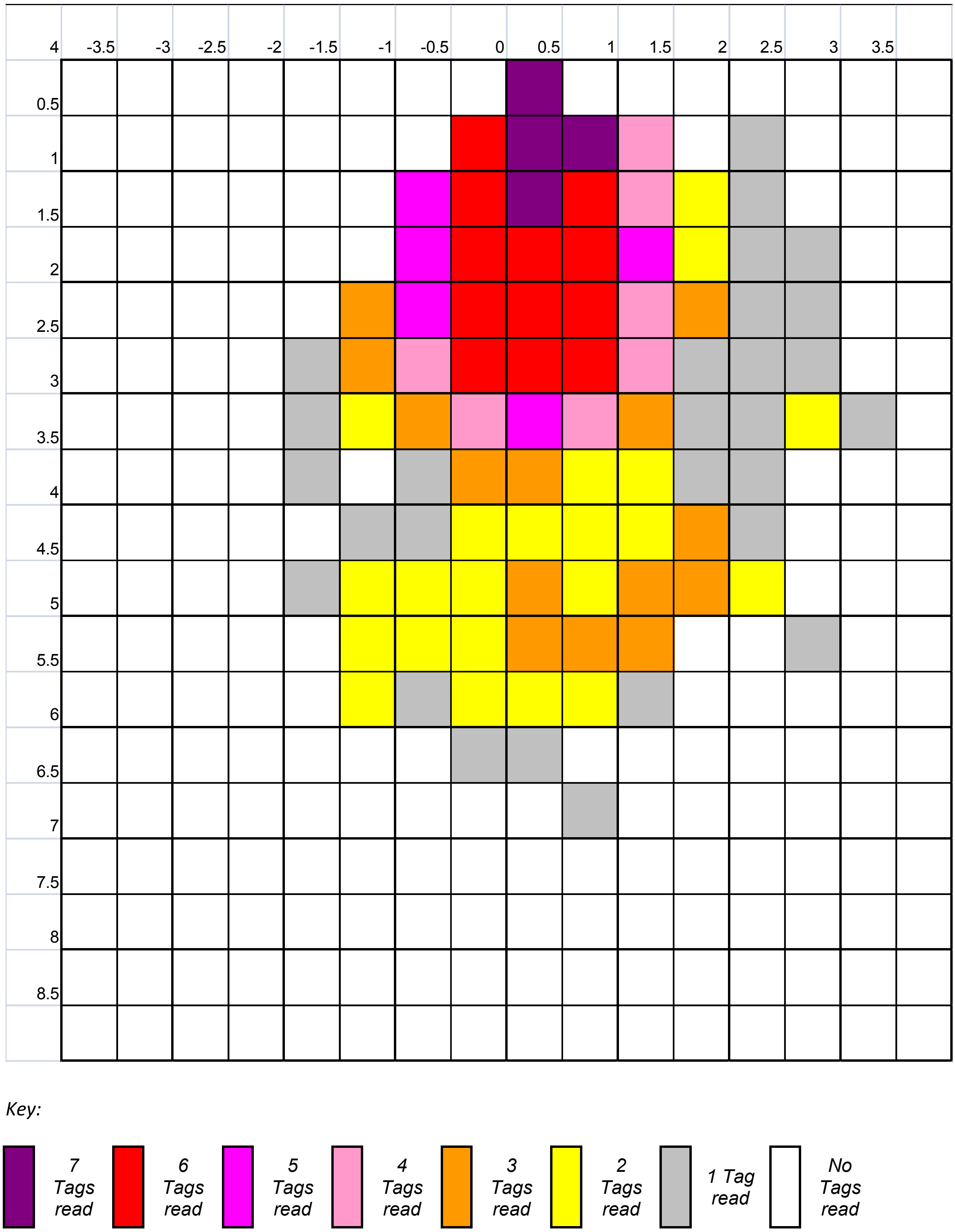


Figure C6: Antennae orientation →, 8dBi gain

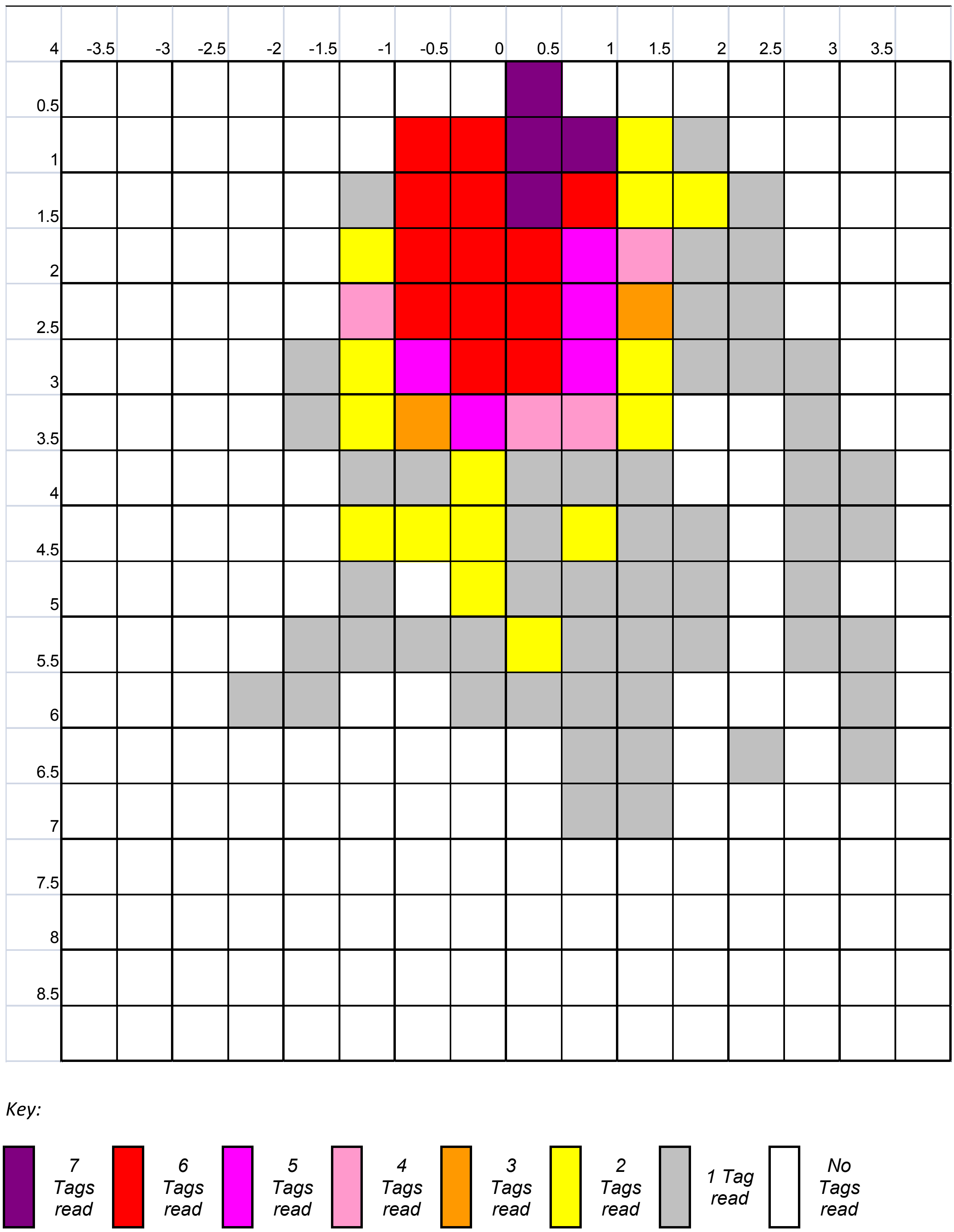


Figure C7: Antennae orientation ↑, 6.15dBi gain

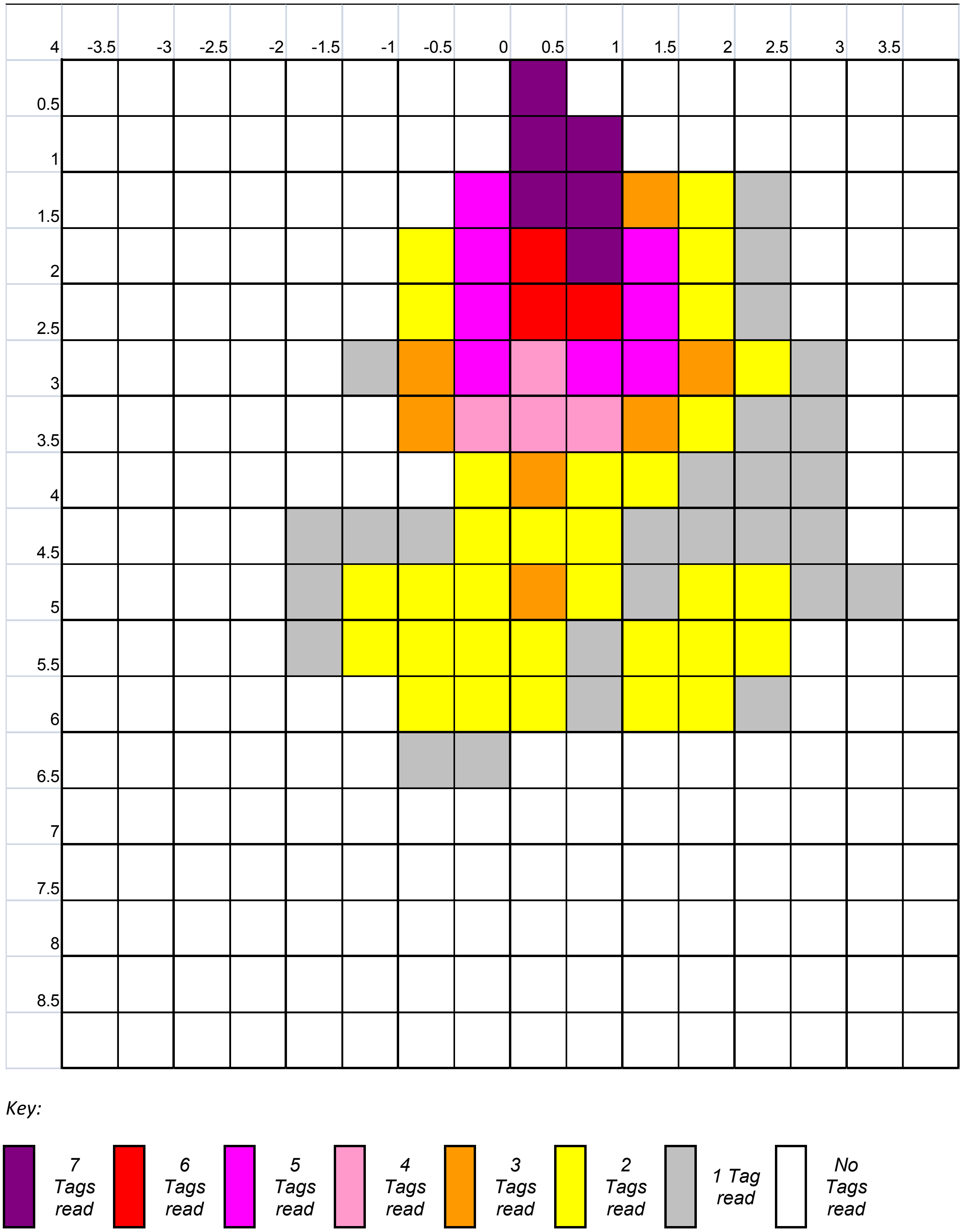
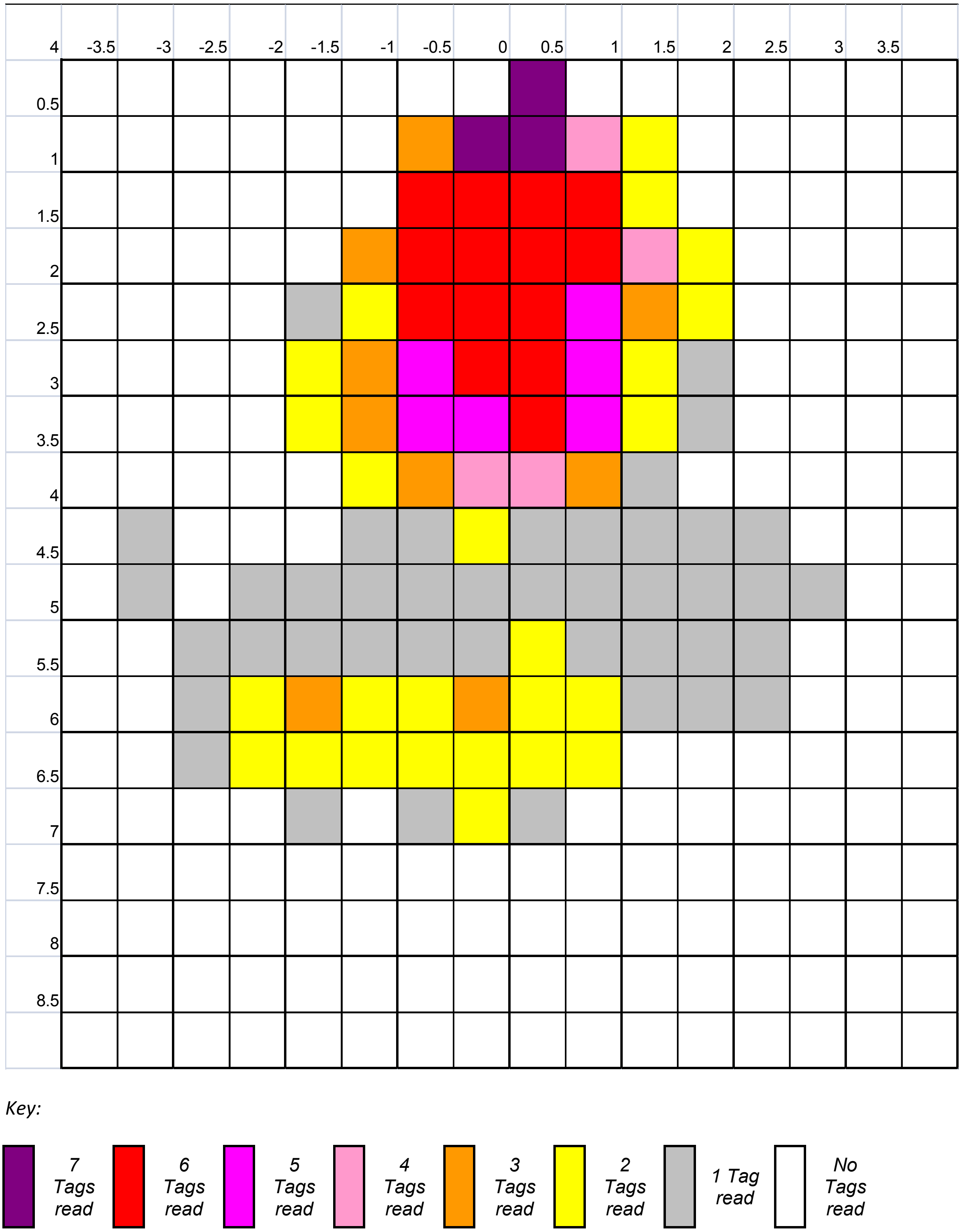


Figure C8: Antennae orientation →, 6.15dBi gain



Appendix D: Proposed allocation of EPC area of UHF Tag (96 bits) under ScotEID.

		Max Value	Size (Bits)	Start Bit	Stop Bit	Fixed sources for additional data
ISO11784 compliant	**Animal Flag**	**1**	1	1	1	
ISO11784 + EC 21-2004	Retag Counter	7	3	2	4	
ISO11784 + EC 21-2004	**Species Code**	15	5	5	9	**See EU Species Codes**
ISO11784	Reserved	0	6	10	15	
ISO11784	Extended Data Flag	1	1	16	16	
ISO11784	**Country Code**	**1023**	10	17	26	**Alpha Lookup from ISO 3166**
ISO11784	**Animal Number**	**274877906943**	38	27	64	
Chrs 1-2 BCMS Barcode	Country code			17	26	Extracted from Bits 17-26 above. ISO3166.
Chrs 3-8 BCMS Barcode	Herd Number			27	64	This would be the situation in a BCMS Passport.
Chrs 10-16 BCMS Barcode	Animal Number					
Chrs 9 BCMS Barcode	Check digit					In a Series 01 BCMS Barcode this would be regenerated the remainder +1 of the decimal value of bits 27 -64 divided by 7. Original Issue Flag ON.
Chrs 15-16 BCMS Barcode	**Birth Year**	99	7	65	71	Can be converted to dd/mm/yyyy format by firmware or software as BCMS type Barcode
Chrs 17-18 BCMS Barcode	**Birth Month**	12	4	72	75	
Chrs 19-22 BCMS Barcode	**Birth Day**	35	5	76	80	
Chrs 23-27 BCMS Barcode	**Breed of Animal**	511	9	81	89	**Alpha Lookup from Breed Code**
Suffix X to above	**Cross**	1	1	90	90	
Chrs 28 BCMS Barcode	**Sex**	3	2	91	92	M or F or Castrate?
Chrs 29-30 BCMS Barcode	Original Issue	1	1	93	93	From BCMS Passport or Not
	Reserved/Spare		2	94	95	
	Ext'd UHF Data Flag	1	1	96	96	Indicates data in UHF Tag User Memory.

Note:

1. In this proposal the least significant bit (LSB) of the EPC Memory is defined as **Bit 1** and the Most Significant Bit (MSB) as **Bit 96**.
2. BCMS Barcode refers to the long 30 alpha numeric barcode at the bottom of a BCMS Passport used in UK Cattle.
3. Bits 1-64 shown in this scheme are wholly compliant with ISO11784 and EC 21-2004. Basic output from a reader can be streamed as ISO 24631-6. The first 64 bits of data output are identical to that of an ISO11784 compliant tag or reader.
4. Bits 65 -96 cater for the additional data held on a BCMS style UK Passport.
5. Data coming from those tags from UHF readers could be directly used by software capable of reading a “normal” 21-2004 type LF tag from a LF RFID reader. Alternatively it can be inputted as if it were the bottom barcode from a passport (as scanned by a barcode reader) and any existing computer software systems would require little or no modification at all.