

Opportunities for research and innovation from involvement in standards development – Experiences of two researchers

Serena Coetzee¹ Antony K Cooper^{1,2}

¹Centre for Geoinformation Science, University of Pretoria, Pretoria, South Africa serena.coetzee@up.ac.za

²Built Environment, CSIR, Pretoria, South Africa acooper@csir.co.za

Abstract

This paper covers the benefits that can be realised by the research and teaching communities, and the benefits and improvements that can be introduced into local and international standards, through exploiting cutting-edge research. We draw on our domestic and international experiences with standards development and academic research to discuss the mutual benefits to researchers and standards developers of close cooperation. We answer the questions:

- How have standards and our involvement in standards influenced our research?
- How has our research influenced standards?
- Have the standards that we were involved in created new opportunities for innovation?
- What are the barriers to implementing standards, thereby inhibiting innovation?
- What are the barriers to involvement in standards development?

From our answers, we identify weaknesses in current standards development, dissemination and use practices. The paper concludes with recommendations for improving both the South African and international standards development practices.

1. Introduction

The South African Bureau of Standards (SABS) has initiated a project to develop and implement a strategy to engage more meaningfully with academic institutions in order to bring the worlds of standards and academia closer together [Visser 2012]. The SABS believes that it is very important for young graduates entering the workplace to be made aware of the world of standardization. The authors were asked to write a discussion paper on *how standards have created new opportunities for research and innovation* for the launch event of this SABS strategy [Coetzee & Cooper 2012]. As a result, we were asked by the SABS to submit a revised version of this paper to the International Conference on Education in Standardisation (ICES) 2012 and WSC Academic Day.

Research is an important criterion against which researchers at South African universities and science councils are measured. Innovation, i.e. introducing new methods, ideas or products, follows research. There is ample scientific evidence that standards support innovation, especially in information technology [Allen

& Sriram 2000, Yoo et al. 2005, Friedrich 2011]. The synergies between research, innovation and standardization are illustrated in Figure 1. Therefore, if academics included standards and standardization in their research, this will have a positive impact, not only on innovation, but also on standardization education.

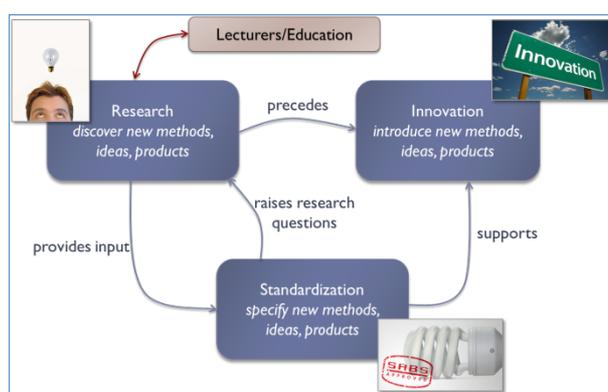


Figure 1: Research, innovation and standardization

In this paper we analyse our own experience as researchers in standards development in order to understand how standards have created new opportunities for research and innovation in our own worlds. We did this by asking ourselves the following questions:

- How have standards and our involvement in standards influenced our research?
- How has our research influenced standards?
- Have the standards that we were involved in created new opportunities for innovation?
- What are the barriers to implementing standards, thereby inhibiting innovation?
- What are the barriers to involvement in standards development?

We address these questions in section 2. In section 3, we provide a summary of mutual benefits among standards, research and innovation, and list barriers that hinder standards-driven innovation. We conclude with recommendations for removing these barriers. The objective of this paper is to encourage the discussion on the involvement of academics in standards development, as well as on standardization education in university curricula.

2. Experiences

We have mainly been involved in the development of geographic information standards since 2006 and 1985 respectively (refer to the note at the end about the authors' involvement). Geographic information is information concerning phenomena implicitly or explicitly associated with a location relative to the Earth [ISO 19101:2002] and plays a central role in service delivery by local governments, for example. Our experience has primarily been of standards development in the International Organization for Standardization's Technical Committee ISO/TC 211, *Geographic information/Geomatics*, and its local mirror committee, SABS/SC71E, *Geographic information*, but we have also been exposed to standards development in industry consortia, such as the Open Geospatial Consortium (OGC), which collaborates closely with ISO/TC 211. Standards development requires expertise and innovation in the domain being addressed (often requiring expertise across disciplines), as well as in standards and standards development themselves. An example of this within ISO/TC 211 is the realisation that standards development can be compared to configuration management in software engineering, which also confirms OGC's route to modular standards, i.e. that, a standard is more a container of normative clauses, rather than an end in itself [Coetzee 2011, Coetzee *et al* 2011].

2.1. How have standards and our involvement in standards influenced our research?

Involvement in standards has made it easier to find and understand standards, their implementations and the implications of standards adoption. For the analysis of a data grid approach for spatial data infrastructures (SDI), being involved in standards made it easier to find and understand the implications of relevant standards, not only those related to the committees and organizations that we are involved in, but also those from other standardization organizations, such as the Open Grid Forum (OGF) and the Organization for the Advancement of Structured Information Systems (OASIS) [Coetzee 2009, Coetzee & Bishop 2009].

Involvement in standards provides an opportunity for networking and we have both used this opportunity to get involved in other research. We contribute to the research of the Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (ICA) [Cooper & Clarke 1991, Cooper 1997, Cooper & Gavin 2005, Hjelmager *et al* 2008]. In turn, participation in the ICA commission has led to a bilateral research project between South Africa and Poland. Another research initiative on the writing and modularity of standards is on-going, in collaboration with other members of ISO/TC 211 [Coetzee *et al* 2011].

Involvement in standards raises many interesting research questions, which we have integrated into research projects. One student investigated the use of standard web services in thematic web maps

[Rautenbach *et al* 2012] on our bilateral research project between South Africa and Poland, while another is experimenting with the use of ontologies for cross-mapping between address specifications [Tewelde & Coetzee 2011]. Results from the latter were used as input for the new work item proposal (NWIP) for ISO 19160-1, *Addressing – Part 1: Conceptual Model*. (currently out for ballot). We have published extensively about our standards related research, amongst others seven articles in peer-reviewed journals, four book chapters, and conference papers in a variety of international conference proceedings.

Google Scholar confirms that there is much research exploiting standards: it records about 7,200 papers with "ISO 9000" in their title, for example. Within geographical information science (GISc), 42 papers in the prestigious International Journal for Geographical Information Science alone reference ISO 19115 [2003], the metadata standard developed by ISO/TC 211, *Geographic information/Geomatics*.

Involvement in standards brings academics into contact with the practitioners [Coetzee *et al* 2008, Coetzee *et al* 2010]. The cross-pollination between these two communities enriches the resultant standards and research. Similarly, involvement in standardization brings one into contact with experts from different cultures, and working on standards then emphasises how different not just languages are from one another, but also education systems and hence the contexts within which experts from different countries understand technologies and standards. This has led us to realise the importance of getting a common understanding of the concepts, terminology and scope, before starting to write the standard or starting an international research project, or even a domestic research project in a multi-lingual and multi-cultural country such as South Africa (e.g. creating a methodology for standards development in an organisation [Cooper 2005]). We have applied this to new standards under development, such as ISO 19152, *Geographic information -- Land Administration Domain Model (LADM)*, and ISO 19160-1, *Addressing – Part 1: Conceptual model*, [Lemmen *et al* 2011, Coetzee *et al* 2010].

2.2. How has our research influenced standards?

The development of the South African standard for the exchange of digital geo-referenced information [Clarke *et al* 1988, Cooper 1988] required extensive research on the nature of geographical information, which also contributed to the research being conducted at the Council for Scientific and Industrial Research (CSIR) at the time. The result was an innovative, relational standard that escaped from the constraints of then current systems.

Results from the analysis of the data grid approach for address data sharing in spatial data infrastructures has provided direction and guidance for work on the South African address standard [Coetzee & Cooper 2007, SANS 1883:2009], as well as the international standard,

ISO 19160, *Addressing*. Results from other research projects, such as the bilateral project mentioned above; a project on institutional address data, funded by the University of Pretoria's research development programme; a THRIIP (industry collaboration) project funded by the Department of Trade and Industry (dti) and AfriGIS; and a grant by the Global Spatial Data Infrastructure Association (GSDI), have all provided further input to these standards.

Results from a normative dependency analysis of geographic information standards [Coetzee 2011] have led to further work in ISO/TC 211 to improve the modularity of standards and to explicitly record dependencies between standards [Coetzee *et al* 2011]. Recommendations will now be implemented in ISO/TC 211 in order to improve the readability, testability and maintainability of standards. In related work by a South Africa colleague, Walker [2011] cross-referenced provisions from quality and process-related standards, including ISO 9001:2008. The effort needed to find and cross-reference requirements confirmed the need for modular standards.

2.3. Did the standards that we were involved in create new opportunities for innovation?

The published South African standard for the exchange of digital geo-referenced information was implemented by the CSIR for two vendors, resulting in the finding that an exchange standard is a language [Cooper 1993] and the development of a formal model for the standard and its encoding in LEX and YACC [Cooper 1994].

Feedback from delegates at standards meetings suggests that the South African address standard has prompted innovation: the South African Post Office is implementing a new address validation system based on SANS 1883:2009 and various private sector companies are promoting SANS 1883-compliant tools. Internationally, we expect a similar trend, once the different parts of ISO 19160 are published. Already now, while the draft is still under development, at least six profiles of ISO 19160-1, *Addressing – Part 1: Conceptual Model*, for various countries and regions are under development. These profiles will spawn addressing tools in the respective countries and regions.

2.4. What are the barriers to implementing standards, thereby facilitating innovation?

There is an acute lack of awareness of the existence of relevant standards. This is evident from the delegates attending our annual 'Introduction to GIS Standards' short course presented by Continued Education at the University of Pretoria (CE at UP). We spend a large part of the first morning educating them on where to find information about standards and how to access these. Occasional queries we receive from the public show that the SABS website does not come up as an option for finding a standard. Could it be that people do not associate the SABS with information technology standards?

A cost of as little as R 1.00 for a standard is a barrier to accessing that standard, because of the bureaucracy that

needs to be dealt with to approve purchases (especially in local authorities). The answer is to have licensing mechanisms for large clients, such as the South African government (all three tiers), if not for the whole country. The CSIR has such a licence, for example.

The readability of a standard, or rather the lack thereof, is a huge barrier. As we have often stated, *a standard is not a novel!* It is written for precision, not for entertainment. Nevertheless, the writing of standards can be improved. This is evident in novice standards users, but also in experienced delegates at standards meetings. It takes a while to understand the implications of 'shall', 'may' and the other verbal forms for the expression of provisions in a standard. Once understood, realization strikes that provisions are often hidden behind other words or phrases, such as 'is a'!

Readability also influences the testability of a standard: if requirements are difficult to find, it is also difficult to test conformance of these requirements. Readability can be improved by the way in which standards are written [Coetzee 2011, Coetzee *et al* 2011], but standardization education on reading, interpreting and writing standards will also improve readability and thus remove barriers to implementation.

Because there is no conformance approval or other incentive for geographic information standards implementation in South Africa, the public and private sector are reluctant to spend money on standards implementation for which there is no explicit financial gain.

2.5. What are the barriers to involvement in standards development?

The Department of Higher Education and Training (DHET) subsidises publications by South African universities in peer-reviewed accredited journals, which are typically reviewed by two to three peers. In contrast, experts from the member bodies of a technical committee scrutinize a standard through several stages before it is accepted. ISO/TC 211, for example, has 63 member bodies and many more liaison organizations. ISO/TC 211's most widely used standard, ISO 19115 (2003), has generally had over 1,000 comments at each stage. Despite this, there is no subsidy for standards from the DHET and therefore support from the universities for standards involvement is lacking. It is sometimes difficult to fund attendance at standards meetings from a research project, because the research in standards development is not recognised. While standards are recognized as a research output at the CSIR (one of several science councils in South Africa), it can also be difficult to participate in standards development, because CSIR staff need to obtain funding to cover their time at charge-out rates.

Another barrier is very limited recognition of, or teaching of, standards at school or university, even though one is continually exposed to standards. The initial focus should be on the undergraduate curriculum for science, engineering, commerce and law – indeed, with their exposure to legislation and policies, students in commerce and law might be more receptive to

standards in the curriculum, and there are many standards relevant to them (e.g. management standards). As a result, the SABS will be targeting business schools to introduce standards to their curricula [Visser 2012].

One problem encountered by those new to the writing of standards is the need to maintain tedious consistency throughout the standard. For example, if clauses are structured exactly the same (i.e. have a lot of text in common in the same places in the clauses), this is because they are equivalent, but for different concepts. Where clauses are structured similarly, this is because they are nearly the same, but there are key differences.

3. Conclusion

In summary, standards, research and innovation have many mutual benefits:

- Involvement in standards development is an opportunity for research networking.
- Involvement in standards development improves one's understanding of standards and their value.
- During standards development, research questions are raised.
- Input from research results has a positive influence on the resultant standard.
- Standards provide opportunities for innovation.
- Cross-pollination between academics and practitioners during standards development enriches resultant research and standards.
- Exposure to the international standards development community is beneficial experience for work on international research projects and for innovation for global markets.

These benefits could drive innovation but are hindered by a number of barriers in South Africa:

- Lack of awareness of standards.
- Costs of standards and the resulting barrier to accessing standards.
- Readability and testability of standards.
- No DHET subsidy incentive to universities for involvement in standards.
- No conformance testing for geographic information standards.

Based on our experience, we recommend the following with the objective of stimulating the discussion on the involvement of academics in standards development and on standardization education in university curricula:

- Students and academics at universities should have free online access to all standards.
- National and provincial government departments, as well as local governments, should have easy online access to relevant standards through a site licensing mechanism.
- Standardization education should be integrated into the undergraduate and postgraduate curricula of tertiary degree programmes.
- The DHET should recognise the research and innovation that go into a standard and include standards in the subsidy mechanism for universities.

- Testing data and products for conformity to geographic information standards should be provided by accredited organizations.
- Standards should be written in a modular fashion for better readability, testability and maintainability.

Acknowledgements

The authors would like to thank the South African Bureau of Standards (SABS) for the invitation to submit this paper and their financial support to participate in the ICES Conference and the WSC Academic Day 2012. We would also like to thank the SABS for their support for SANS 1883, *Geographic information – Addresses* and ISO 19160, *Addressing*, as well as the financial support to the authors to attend meetings of ISO/TC 211, *Geographic information/Geomatics*, and other standards-related meetings.

A preliminary version of this paper was presented by Dr Coetzee at the South African Bureau of Standards (SABS) Academics Open Day, 1 March 2012 [Coetzee & Cooper 2012], and we thank the SABS for the invitation to make the presentation.

References

- Allen RH and Sriram RD (2000). The role of standards in innovation. *Technological Forecasting and Social Change* **64**:171-181.
- Clarke DG, Cooper AK, Liebenberg EC & Van Rooyen MH (1988). On proposing a national standard for the exchange of digital geo referenced information, *South African Journal of Photogrammetry, Remote Sensing and Cartography*, 15(1), pp 35-41.
- Coetzee S (2009). *An analysis of a data grid approach for spatial data infrastructures*, PhD dissertation, University of Pretoria, Pretoria, South Africa.
- Coetzee S (2011). Results from a normative dependency analysis of geographic information standards. *Computer Standards and Interfaces* **33**(2011), pp. 485-493, DOI: 10.1016/j.csi.2011.02.004.
- Coetzee S and Bishop JM (2009). An analysis of technology choices for data grids in a spatial data infrastructure in *Spatial Data Infrastructure Convergence: Research, Emerging Trends, and Critical Assessment* B van Loenen, JWJ Zevenbergen and JA Besemer (Editors), Nederlandse Commissie voor Geodesie/Netherlands Geodetic Commission, 48, 2009.
- Coetzee S and Cooper AK (2007). What is an address in South Africa?, *South African Journal of Science (SAJS)*, Nov/Dec 2007, 103(11/12), pp449-458.
- Coetzee S & Cooper AK (2012). Opportunities for research and innovation from involvement in standards development – Experiences of two researchers. Discussion paper. South African Bureau of Standards (SABS) Academics Open Day, 1 March 2012, 6pp.

- Coetzee S, Cooper AK, Lind M, McCart Wells M, Yurman SW, Wells E, Griffiths N and Nicholson MJ (2008). Towards an international address standard, *GSDI-10 Conference*, Trinidad and Tobago, 25-29 February 2008.
- Coetzee S, Cooper AK, Piotrowski P, Lind M, McCart Wells M, Wells E, Griffiths N, Nicholson MJ, Kumar R, Lubenow J, Lambert J, Anderson C, Yurman SW, and Jones R (2010). What address standards tell us about addresses (long version), *ISOFocus+ Online*, International Organization for Standardization (ISO), Geneva, Switzerland, June 2010.
- Coetzee S, Cox S and Herring J (2011). Configuration management of a system of interdependent standards. *7th International Conference on Standardization and Innovation in Information Technology (SIIT)*, Berlin, Germany, 28-30 September 2011.
- Cooper AK (1988). A data structure for exchanging geographical information, *Quaestiones Informaticae*, 6(2), pp 77-82.
- Cooper AK (1989). A survey of standards for the exchange of digital geo referenced information, *South African Journal of Photogrammetry, Remote Sensing and Cartography*, Vol 15, Part 3, pp 136-140.
- Cooper AK (1993). *Standards for exchanging digital geo-referenced information*, unpublished MSc thesis, University of Pretoria, South Africa, 247 pp.
- Cooper AK (1994). A formal specification of the National Exchange Standard (NES), Version 2.0, *South African Journal of Photogrammetry and Geo-information*, Vol 16, No 5, pp 131-141.
- Cooper AK (1997). South Africa: National Standard for the Exchange of Digital Geo-referenced Information (NES), in Moellering H & Hogan R, eds, *Spatial database transfer standards 2: characteristics for assessing standards and full descriptions of the national and international standards in the world*, International Cartographic Association and Pergamon, pp 225-235, ISBN 0-08-042433-3.
- Cooper AK (2005). *Proposed methodology and infrastructure for standards development and implementation within a national statistical agency*, 14th Conference of the Commonwealth Statisticians, Cape Town, South Africa, 8 September 2005.
- Cooper AK and Clarke DG (1991). The South African standard for the exchange of digital geo referenced information, in Moellering H, ed, *Spatial database transfer standards: current international status*, International Cartographic Association and Elsevier Applied Science, pp 154-168, ISBN 1-85166-677-X.
- Cooper AK and Gavin EJO (2005). Metadata in Africa and the Middle East, in Moellering H, Aalders HJGL & Crane A, eds, *World Spatial Metadata Standards: Scientific and Technical Characteristics, and Full Descriptions with Crosstable*, Elsevier and the International Cartographic Association, pp 431-450, ISBN: 0080439497.
- Cooper AK and Zietsman HL (1999). Spatial Entity Classification Standard (SpECS): A Proposed Standard for South Africa, *South African Journal of Surveying and Geo-information*, Vol 1, No 3, pp 137-152.
- Friedrich J (2011). Making innovation happen: The role of standards and openness in an innovation-friendly ecosystem. *7th International Conference on Standardization and Innovation in Information Technology (SIIT)*, Berlin, Germany, 28-30 September 2011.
- Hjelmager J, Moellering H, Cooper AK, Delgado T, Rajabifard A, Rapant P, Danko D, Huet M, Laurent D, Aalders HJGL, Iwaniak A, Abad P, Düren U & Martynenko A (2008). An initial formal model for spatial data infrastructures, *International Journal of Geographical Information Science (IJGIS)*, Vol 22, No 11&12, pp 1295-1309.
- ISO 9001:2008, *Quality management systems – Requirements*, International Organization for Standardization, Geneva, Switzerland.
- ISO 19101:2002, *Geographic information – Reference model*, International Organization for Standardization, Geneva, Switzerland.
- ISO 19115:2003, *Geographic information – Metadata*, International Organization for Standardization, Geneva, Switzerland.
- ISO/TC 211 *Geographic information/Geomatics* (2011). *Review summary of ISO 19160, Addressing*, available online at <http://www.isotc211.org/address/iso19160.htm> (accessed 17 February 2012).
- Lemmen CHJ, van Oosterom PJM, Uitermark HT, Zevenbergen JA & Cooper AK (2011). *Interoperable Domain Models: The ISO Land Administration Domain Model LADM and its External Classes*, UDMS 2011, Delft, The Netherlands, 28-30 September 2011.
- SANS 1883:2009, *Geographic information – Addresses*, South African Bureau of Standards (SABS), Pretoria, South Africa.
- Tewelde N and Coetzee S (2011). *Address Ontology*, presented at the project meeting of ISO 19160, *Addressing*, Centurion, South Africa, 14 November 2011.
- Rautenbach V, Coetzee S and Iwaniak A (2012). *Orchestrating OGC web services to produce thematic maps in a spatial information infrastructure*, submitted.
- Visser G (2012), *Education on Standardisation in South Africa*, International Conference on Education in Standardisation (ICES) 2012 and WSC Academic Day, Bali, Indonesia, 9-11 May 2012.

Walker AJ (2011). *Evaluating the ISO TMB Management System Common Text proposal in terms of selection of candidate management system standards*, SPI Laboratory (Pty) Ltd, Johannesburg, South Africa.

Yoo Y, Lyytinen K and Yang H (2005). The role of standards in innovation and diffusion of broadband mobile services: the case of South Korea. *Journal of Strategic Information Systems* **14**: 323-353.

About the authors' involvement in standards development and education

Mr Antony Cooper was appointed to the CSIR in 1985 to develop the South African standard for the exchange of digital geo-referenced information. He currently chairs SABS/SC 71E, *Geographic information*. He has attended every Plenary of ISO/TC 211, *Geographic information/Geomatics*, since 1999, was Convenor of Working Group 2, *Geospatial data models and operators*, and is currently Convenor of Working Group 7, *Information Communities*. He has also participated in two Plenaries of ISO/TC 69, *Applications of statistical methods*, in several other SABS committees, and chairs the Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (ICA).

Dr Serena Coetzee was the project leader for the South African Address standard, which was initiated in 2006 and published in 2009 (SANS 1883:2009). She is the project leader of ISO 19160, *Addressing*, and chairs the Programme Maintenance Group of ISO/TC 211, which monitors the committee's programme of work to ensure harmonization and consistency among standards. Serena is also a member of the ICA Commission on Geoinformation Infrastructures and Standards. She is the Programme Chair for the academic track for the GISSA Ukubuzana 2012 conference, to be held in October 2012 in Ekurhuleni, South Africa.