

## STRATEGIES FOR UNDERSTANDING LIGHTNING MYTHS AND BELIEFS

**\*E. Trengove & I.R. Jandrell**

School of Electrical and Information Engineering, University of the Witwatersrand, Private Box X3, WITS, 2050, South Africa

**\*Email:** Estelle.Trengove@wits.ac.za

### ABSTRACT

In South Africa, lightning kills people every year. People who work outdoors are particularly vulnerable to lightning strikes. Strategies need to be developed to reduce the number of people killed or injured by lightning. Many people, however, have firm views and beliefs about lightning and any strategy to improve their safety with respect to lightning, will have to take cognisance of these beliefs. This paper looks at the strategies that engineers can follow to familiarise themselves with the lightning beliefs in rural areas in Southern Africa.

### 1. INTRODUCTION

In South Africa, lightning kills and injures people and animals and damages property every year.

In November 2010, for example, seven people were killed and forty were injured when a crèche was struck by lightning in the KwaZulu-Natal [1].

There are no countrywide statistics on lightning deaths, but a quick survey of the newspapers and on-line news websites in Table I shows that 84 people were killed by lightning in South Africa between early January 2009 and late November 2010. This number is likely an under-estimate since reports in the lay press depend on whether the information reaches them and on whether it is deemed more interesting than other news items competing for the same space.

Rural people who work outdoors tending the land or herding animals are particularly vulnerable to lightning strikes. In addition to people who are killed by lightning, there are no records of how many people are injured by lightning strikes, but there could potentially be a large number of rural people who are affected.

Recent research in Gauteng showed that 52 people were killed by lightning during the period 2001 – 2004 [2]. All the deaths occurred outdoors and out of town – none happened in Johannesburg. Statistics on lightning deaths in South Africa have, however, never been systematically collected countrywide.

Strategies have to be devised to reduce the annual number of lightning deaths in South Africa.

**Table I:** Press reports of lightning deaths in South Africa

Source	Publication date	Number of deaths	Place of occurrence
IOL News	05-01-2009	5	Kwamashu (KZN)
IOL News	11-01-2009	1	Bhamshela (KZN)
SABC News	02-02-2009	3	Majabe Village (EC)
news24	26-11-2009	2	Elliotdale (EC)
news24	26-11-2009	2	Mquandile (EC)
news24	26-11-2009	1	Enqcobp (EC)
Daily Dispatch	26-11-2009	14	Transkie (EC)
Daily Dispatch	28-11-2009	2	Mqandule (EC)
Daily Dispatch	28-11-2009	1	Nqobo (EC)
Daily Dispatch	28-11-2009	2	Eliotdale (EC)
Daily Dispatch	28-11-2009	1	Dumsi (EC)
IOL News	02-12-2009	1	Vereeniging (Gauteng)
BEELD	03-12-2009	1	Vaaldriehoek (MPL)
IOL News	10-01-2010	1	Nkwenkwana Village (EC)
IOL News	10-01-2010	1	Mthatha (EC)
Daily Dispatch	12-01-2010	4	Rhoda Village (EC)
IOL News	11-01-2010	3	Enqobobo (EC)
IOL News	11-01-2010	1	Qumbu (EC)
IOL News	19-01-2010	2	Qumbu (EC)
news24	25-01-2010	1	Okhukho (KZN)
STAR	18-02-2010	3	Mid-Illovo (KZN)
IOL News	26-02-2010	6	Jece Village (EC)
Sowetan Live	07-05-2010	1	Tlhalane (NW)
IOL News	08-10-2010	1	Mpikwana (EC)
IOL News	08-10-2010	1	Mthatha (EC)
news24	08-10-2010	1	Midrand (Gauteng)
IOL News	18-02-2010	3	Mid-Illovo (KZN)
news24	25-10-2010	1	Tzaneen (Limpopo)
news24	25-10-2010	3	Nkumbi (KZN)
news24	25-11-2010	1	Eesterust (Gauteng)
IOL News	30-10-2010	1	Soweto (Gauteng)
IOL News	09-11-2010	1	Soweto (Gauteng)
Sowetan Live	12-11-2010	1	Thohoyandou (Limpopo)
IOL News	23-11-2010	4	Port St. John (EC)
news24	27-11-2010	7	Pongola (KZN)
<b>TOTAL</b>		<b>84</b>	

A project that was initiated in 2009 to attempt to understand Southern African traditional myths related to lightning and to examine how these could inform strategies for increasing the safety of rural communities.

This paper gives an overview of the strategies that engineers can employ to gain insight into lightning-related myths and beliefs and some examples of implementing each one. To gain an understanding of these myths and beliefs, engineers have to venture into fields that are unfamiliar to them, such as literature, oral tradition, anthropology and interviewing.

## 2. MOTIVATION

The question might be raised as to why engineers should go to these lengths to understand local myths and beliefs about lightning and the answer lies in professional ethics and codes of conduct to which engineers subscribe. The Code of Professional Conduct of the Engineering Council of South Africa (ECSA) [3] is used for illustrative purposes, but many engineering codes of conduct worldwide contain similar clauses.

A code of conduct can be described as a set of rules that prescribes how the members of a profession are to conduct themselves in matters pertaining to their professional lives. ECSA's Code of Professional Conduct is entrenched in South Africa's legislation in the South African Engineering Profession Act 46 of 2000 [3] and this means that everybody registered as a professional engineer by ECSA is bound by it.

The Code consists of a number of rules, introduced by a paragraph stating that the rules are, amongst other things, to ensure that registered professional engineers:

- “apply their knowledge and skill in the interest of humanity and the environment”;
- “respect the interests of their fellow beings”.

Furthermore Rule 2(a) in the Code states that engineers “must have due regard to public safety, public health and the public interest generally”.

It is evident from these sections of the Code of Conduct that engineers should care about and take into consideration the local beliefs when they interact with communities.

In a country with a homogenous population, this would not be such an issue. In a country like South Africa, however, there is large diversity of groups with different languages and cultural identities. The challenge to engineers introducing technology into an area is to understand and accommodate such local views.

A second motivation for this work comes from a growing interest in South Africa in so-called indigenous knowledge systems, which involves harnessing indigenous knowledge in various ways. A recent example is the commercialisation of dieting products containing hoodia. Hoodia is a plant that was used by the San to control their appetites during periods when food was scarce. In a similar way, by interacting with communities, engineers might learn something of interest by subjecting their indigenous knowledge to scientific scrutiny.

### 3. ORAL TRADITION

A rich oral tradition existed in indigenous communities in Africa long before the skill of writing was introduced by missionaries and other literate Europeans that came into contact with them. Most of what we know today, for example, about the language and culture of the original San hunter-gatherers who lived in the Kalahari, was recorded by Dr Wilhelm Bleek, a German linguist, who came to South Africa in 1855 to compile a Zulu grammar [4].

Bleek was interested in the San and heard that there were some San prisoners in Cape Town and on Robben Island. He started interviewing some of the San prisoners and later got permission to employ some who were unfit for hard labour, where they taught him their language and he recorded and translated their tales.

His sister-in-law Lucy Lloyd and, later, his daughter Dorothea Bleek, continued with his work on the San, which comprises about 12 000 pages. The collection is currently housed in a library at the University of Cape Town.

The old San tale of †kagara and !haunu, transcribed by Bleek and later published in a collection entitled *Specimens of Bushman Folklore* [5], deals with lightning.

The use of the symbols † and ! in the names †kagara and !haunu is explained by Lucy Lloyd in the preface to *Specimens of Bushman Folklore* [5]. The San language comprised a number of click sounds that were not used in any of the written languages at the time, so symbols were used to represent the different clicks. The † symbol denotes a palatal click, which is made by pressing the tip of the tongue to the front of the palate, where it meets the gums, and withdrawing it quickly. The ! symbol indicates a cerebral click, made by curling the tip of the tongue against the roof of the palate and withdrawing it quickly.

In the story, †kagara fetches his younger sister from her husband !haunu, to take her back to her parents. !haunu follows them and uses lightning to fight †kagara. †kagara then retaliates with “black lightning”. A footnote in Bleek’s notes explains that “black lightning is the lightning that kills”.

The San narrator concluded the story by saying that his grandmother used to say that it was †kagara and !haunu whenever there were heavy clouds and lightning in the East.

The story is relevant in the context of lightning myths and beliefs in Southern Africa in the sense that it refers to beings that are able to control lightning. One of the reasons why this research project is relevant is that there are many people in South Africa today that believe that witches have the power to control lightning so that it selectively kills or injures livestock and people or destroys houses [6]. Any attempt to help communities become safer from lightning, will have to incorporate this view of the world.

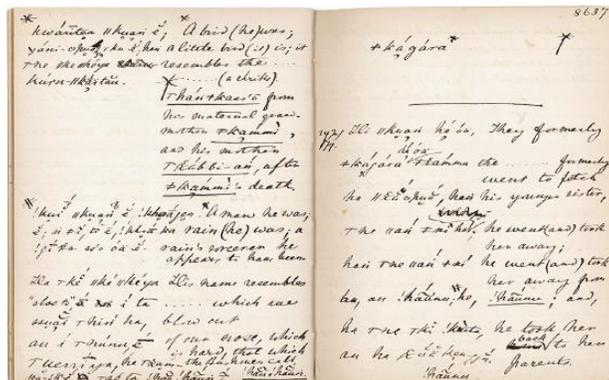


Figure 1. Wilhelm Bleek’s record and translation of the story of †kagara and !haunu from the Bleek and Lloyd archives [7].

For the sake of completeness, the story, as translated in *Specimens of Bushman Folklore* [5], is reproduced in its entirety:

### ‡kagara and !haunu, who fought each other with lightning

“They formerly, ‡kagara formerly went to fetch his younger sister, he went to take her away from !haunu; he took (her) back to her parents.

“!haunu gave chase to his brother-in-law, he passed along behind the hill.

The clouds came, clouds, which were unequalled in beauty; they vanished away.

‡kagara said: “Thou must walk on.” His younger sister walked, carrying (a heavy burden of) things, (her) husband’s things. He (‡kagara) said: “Thou must walk on; for, home is not near at hand.”

“!haunu passed along behind (the hill).

The clouds came, the clouds vanished away.

“‡kagara said: “Thou must walk on, for, thou art the one who dost see.” And he, because the house became near, he exclaimed: “Walk on! Walk on!” He waited for his younger sister, his younger sister came up to his side. He exclaimed: “What things can these be, which thou dost heavily carry?”

“Then !haunu sneezed, on account of it; blood poured out of his nostrils; he stealthily lightened at his brother-in-law. His brother-in-law fended him quickly off, his brother-in-law also stealthily lightened at him. He quickly fended off his brother-in-law. His brother-in-law also lightened at him. He (‡kagara) said: “Thou must come (and) walk close beside me; for, thou art the one who dost see that husband does not allow us time; for, he does not singly lighten.”

“They (‡kagara and !haunu) went along angry with each other. !haunu had intended that he should be the one lightening to ‡kagara to whisk away ‡kagara. ‡kagara was the one who was strong, he continued to fend off his younger sister’s husband, !haunu. His younger sister’s husband was also lightening at him; he was lightening at his brother-in-law. Then he stealthily lightenend at his younger sister’s husband with black lightning, he, lightning, whisked him up (and carried him to a little distance).

“His younger sister’s husband, in this manner, lay dying; he, in this manner, he thundered, while ‡kagara bound up his head with the net, he, arrived at home.

“He went to lie down in the hut, while !haunu lay thundering; he thundered there, while ‡kagara went to lie down, when he had rubbed them (i.e. himself and his younger sister) with buchu, buchu, buchu, buchu, he lay down.”

## 4. ANTHROPOLOGY

Although engineers are not qualified to do anthropological studies, work done by anthropologists can be a source of information about the beliefs of people. Anthropology is the humanities discipline devoted to studying people. According to the MIT (Massachusetts Institute of Technology): “Anthropology studies humankind from a comparative perspective that emphasizes the diversity of human behavior and the importance of culture in explaining that diversity” [8].

One of the well-known methodologies used by anthropologists to collect information, is ethnography. Ethnography is learning about something by doing it yourself, for example if you want to learn about the beliefs of the Zulu people, instead of interviewing some Zulus, you go and live with them and learn about them by becoming part of their community.

Two examples of anthropological studies of the Zulu people are Bishop Henry Callaway’s *The religious system of the Amazulu* [9] and Axel-Ivar Berglund’s *Zulu Thought Patterns and Symbolism* [10].

The texts by Berglund and Callaway were identified by Ana Maria Monteiro-Ferreira as major works on Zulu religion and history in a study in which she re-evaluates Zulu religion [11].

Berglund gives a very detailed account of Zulu beliefs in his book *Zulu Thought Patterns and Symbolism* [10]. His parents were missionaries and he grew up with Zulu playmates, fluent in Zulu. He himself later became a missionary. According to Berglund, thunder is attributed to the Zulu sky deity, *iNkosi yaphezulu*. Thunder is characterized as either male or female. Male thunder is just noise, without lightning, which precedes rain. Female thunder, on the other hand, is accompanied by lightning and can produce sudden and violent storms, which are a result of the sky deity’s destructive anger.

Lightning is said to be a bird, sent by the sky deity. Another view is that it is fire in the shape of a bird. Yet another view is that lightning consists of fire, but the fire is brought to earth by a bird. Sometimes the bird comes to earth to lay eggs.

Significantly, Berglund [10] says that people who are killed by lightning are said to have been taken by the sky deity and do not become shades. *Shades* is the term he uses for the spirits of the forefathers, who intercede on behalf of their family members with the sky deity. This means that those killed by lightning are truly dead to their families.

Such a person may not be buried near the home and must be buried in damp earth, to cool the body, otherwise there will be a drought.

Berglund [10] reports a strong belief that lightning is attracted to things that are white or shiny. White cattle are removed from the kraal and driven away. White fowl are chased away. White and shiny things are covered with dark coloured blankets. Fires are extinguished and people stay in the darker parts of their huts, as far from the door as possible.

According to Berglund [10], men who have had a close encounter with lightning are believed suitable to become heaven-herds. A heaven-herd uses tools and medicines in rituals to drive away storms and lightning. Heaven herds and herbalists can prepare various types of medicine to ward off lightning. Some medicines are made from black stone that comes from places frequently struck by lightning. Another method of protection is to smear a stick with sheep's fat and medicine and to poke the stick into the thatch of a hut.

Werner [12] also refers to the belief that heaven herds are able to turn away hail and lightning. She and Berglund both describe a ritual of how a person becomes a heaven herd – a trained heaven herd makes incisions all over the trainee's body and rubs medicine into them. The heaven herds wave a stick in the air and "scold" the heaven to chase away the lightning.

Bishop Henry Callaway [9] quotes Umbebe, a very old Zulu man as saying that if cattle were struck by lightning, people accepted that the lord had done it to feed himself and the village would prosper, but if a person was struck and died, people would say that it was because the lord had found fault with him.

## 5. LITERATURE

Literature can sometimes give clues about local myths and beliefs.

An example of literature providing a clue about local myths and beliefs about lightning is a short story entitled *The Day Mabata-bata Exploded*, by Mozambican writer Mia Couto [13]. Mozambique was ravaged by a civil war which started in the 1970's and only ended in the 1990's. A legacy of that war was many areas were riddled with land mines, which still render potential farmlands unusable today. In Couto's story, a rural boy takes the family's cattle out to a nearby hill nearby to graze. He sees how a bright flash kills one of his cows and immediately attributes it to the "lightning bird". He is unaware that it was a land mine that killed his cow – he does not know about land mines, but tales about the lightning bird are familiar to him and therefore he confuses the detonation of a land mine with the lightning bird appearing to him in a blinding flash.

## 6. INTERVIEWING

Interviewing community members is another technique that engineers can use to gain insight into local myths and beliefs about lightning. Interviews can either take the form of structured or unstructured interviews. These techniques are familiar to engineers from, for example, requirements elicitation in software engineering [14].

Unstructured interviews are akin to conversations with individual interviewees. The interviewer sets the agenda by choosing which questions to ask, while at the same time, it allows the interviewer to change direction and adapt if required by the responses. Interviews should be recorded so that they can be transcribed and analysed if necessary, but with something as specific as lightning myths and beliefs, sometimes a trend quickly becomes obvious as discussed below concerning interviews with the Khomani San community.

Structured interviews can take the form of questionnaires, like the questionnaire given to high school learners in KwaZulu-Natal, also described below.

The approach that is being followed for this study is to use the other sources from the fields of oral tradition, anthropology and literature to inform the questions for both structured and unstructured interviews.

### a. Unstructured interviews

A pilot study was conducted with the Khomani San community in the Northern Cape. The Khomani San are the descendants of the original hunters and gatherers that lived in the Kalahari. They were evicted from their ancestral land soon after the formation of the Kalahari Gemsbok National Park in 1931 [15] (now the Kgalagadi Transfrontier Park).

Colonialism and apartheid scattered the San people and all but destroyed their language and culture [16]. At present, some of the remaining groups of Khomani San lives at Witdraai and Blinkwater, just outside the Kgalagadi Transfrontier Park.

The most striking feature of the interviews and conversations conducted with members of the community, was the firm conviction that the *witgat* tree is "never struck by lightning".

The *witgat* tree is the *boscia albitrunca*, also called a Shepherd's Bush. The next step in this study was to establish whether there might be any scientific foundation for the Khomani San's view that the *boscia albitrunca* is "never struck by lightning".

One of the reasons why the *boscia albitrunca* might be less susceptible to lightning might be its natural distribution. Superficial observations show that in general, the Camel Thorn (*acacia erioloba*) trees are tall trees, whereas the *boscia albitrunca* tend to be shorter, stockier trees. It is easy to find examples of Camel Thorn trees that have obviously been struck by lightning. A leading reference on Southern African trees [17] describes the Camel Thorn as a tree that can grow up to 16m high, whereas the *boscia albitrunca* is characterised as a stocky tree that can grow up to 7m tall. From the point of view of protecting oneself against lightning injury, however, this would still not exclude a *boscia albitrunca* from being struck and it would, therefore, still not be a good idea to shelter under one during a lightning storm.

Another possible explanation was thought to be the hydraulic lift effect [18], a mechanism whereby deep roots absorb water during the night from deep soil layers, which is then released back into the soil by shallow roots, effectively re-hydrating the shallow soil layers.

When lightning strikes a tree, the mechanism most likely to cause injury or death to people and animals, would be the step potential in the vicinity of the tree. A step potential is a high voltage gradient in the ground radiating from the point of strike [19]. Soil resistivity plays an important role in the magnitude of the step potentials around a point of lightning impact. The lower the soil resistivity, the lower the step potentials around the point of impact.

Soil resistivity varies for different types of soil. It is defined as the resistance between opposite faces of a one-metre cube of soil [20]. Typically, the resistivity of sandy soil in arid areas is much higher than that of clay soils [21]. Soil resistivity is very dependent on moisture content [22] – the more moist the soil, the lower its resistivity.

The hypothesis was that the hydraulic lift effect of the root systems of the *boscia albitrunca* might keep the soil around those trees more moist than the soil under, for example, the Camel Thorn trees in the same area. If that is indeed so, then it would certainly be “safer” under a Shepherds’ Tree than under a Camel Thorn. This hypothesis was tested by conducting soil resistivity tests in the Kalahari. One set of measurements was taken under a *boscia albitrunca* and a control set of soil resistivity measurements was taken 40m away. The results are shown in Figure 2.

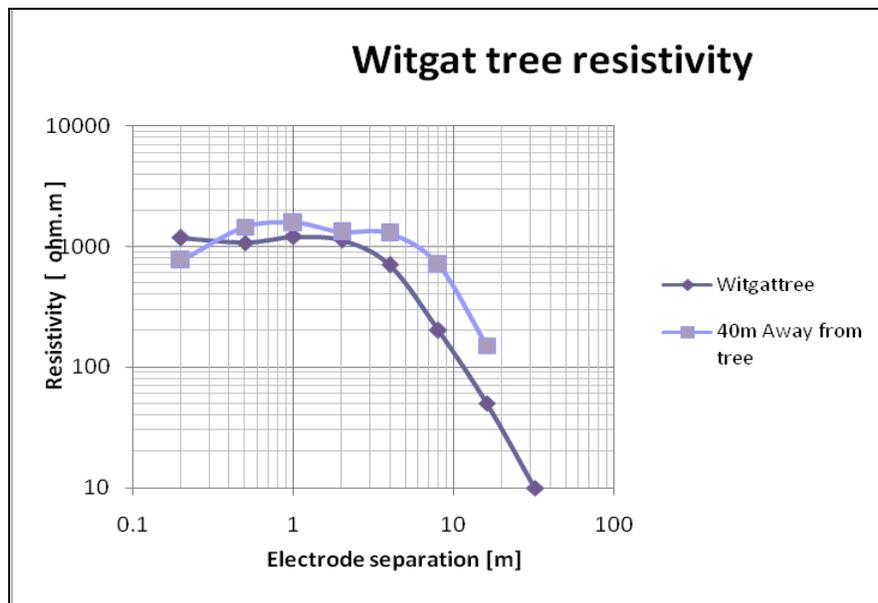


Figure 2. Kalahari soil resistivity measurements

A greater electrode separation implies a larger soil volume and thus a deeper measurement. The measurements indicate that the soil resistivity drops off sharply in deeper layers of soil. This could indicate that deeper levels of soil are moister. It could also be related to the salt and mineral content of the deeper soil levels.

The soil resistivity measurements under the tree and 40m away do not show a significant difference. Based on these results, we believe that there is no convincing proof that the *boscia albitrunca* is less likely to be struck by lightning than any other tree and it would, therefore, not be advisable to shelter under it during an electric storm.

#### b. Structured interviews

A structured interview questionnaire was compiled and used to gain information from school children in the rural town of Hlabisa in KwaZulu-Natal. KwaZulu-Natal is one of the nine provinces in South Africa and is the area to

which most Zulu people can trace their origins. It is still populated predominantly by Zulus. It is also the part of the country that has a lightning ground flash density of about 6 -7 ground flashes/km<sup>2</sup>/year.

Somfula High School has 1050 learners in total. The medium of instruction is English. The questionnaire was given to the Grade 11 learners (about 16 years old).

The aim of one of the questions was to test whether the descriptions given by Berglund (see Section 3 above) still hold true. According to Berglund [10], Zulus believe that lightning is attracted to shiny objects, thus one of the questions posed in the questionnaire was: “Do mirrors attract lightning?” They were given tick boxes where they could select *Yes*, *No* or *Don't know* in response to the question. Those questionnaires that had more than one box ticked or nothing ticked, were counted as spoilt. As shown in Figure 3, the overwhelming majority (91%) of the learners believe that mirrors attract lightning.

To test whether there are still members of the community that believe that there are people who can control lightning, like the heaven herds described by Berglund [10] and Werner [12], the questionnaire posed the question: “Are there people who can control lightning?” A breakdown of the responses is shown in Figure 4.

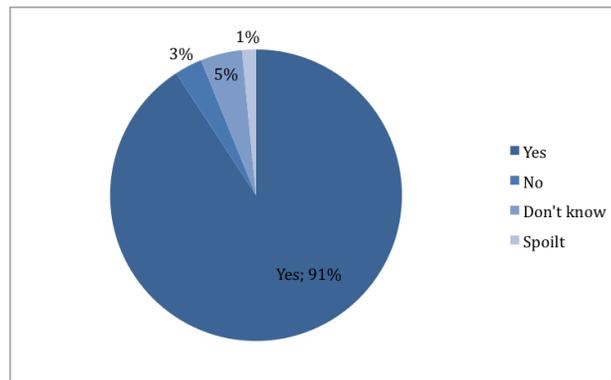


Figure 3. Responses to question: "Do mirrors attract lightning?"

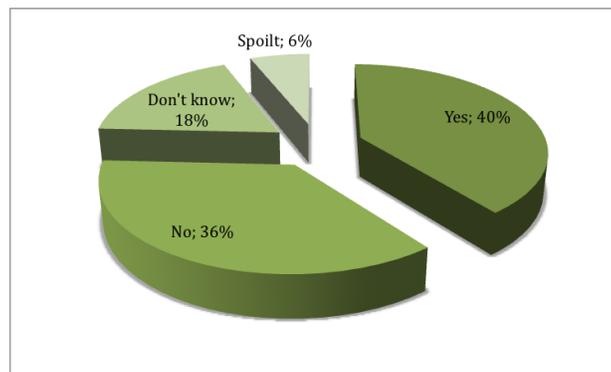


Figure 4. Responses to question "Are there people who can control lightning?"

Again, as can be seen, the majority of the group believe that there are people who can control lightning. The next question in the questionnaire asked respondents to explain who those people are who can control lightning and provided some space for the responses. The most common answer amongst the 40% that believes that there are people who can control lightning, is traditional healers and witches.

**7. CONCLUSION**

It is possible that the beliefs and misconceptions that people have around lightning might either endanger them or help to protect them against lightning.

Either way, it is important to understand and test those beliefs before any attempt can be made to improve the safety of communities.

This paper demonstrates that in order to design effective protection strategies, engineers have to break out of their knowledge silos and explore other areas of knowledge in order to understand the communities that they are working

with. The paper proposes some strategies that engineers can use to get a better understanding of rural myths and beliefs surrounding lightning.

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## 9. REFERENCES

- [1]. 7 die, 40 hurt as lightning strikes crèche, News 24, <http://www.news24.com/SouthAfrica/News/7-die-40-hurt-as-lightning-strikes-creche-20101127>, last accessed 18 January 2011.
- [2]. Jandrell, IR, Blumenthal, R, Anderson, RB & Tregove, E, *Recent Lightning Research in South Africa with a Special Focus on Keraunopathology*, Proceedings of the 16th International Symposium on High Voltage Engineering, Cape Town, August 2009.
- [3]. Engineering Council of South Africa, Code of Professional Conduct, <http://www.ecsa.co.za/Legal/CodeConduct.html>, last accessed 11/07/2002.
- [4]. Lewis-Williams, JD, *Stories that float from afar: ancestral folklore of the San of southern Africa*, David Philip, Cape Town, 2000.
- [5]. Bleek, WHI & Lloyd, LC, *Specimens of Bushmen folklore*, Struik, 1968.
- [6]. Hund, J, *Witchcraft violence and the law in South Africa*, 1st edn, Protea Book House, Pretoria, 2003.
- [7]. [http://lloydbleekcollection.cs.uct.ac.za/data/books/BC\\_151\\_A2\\_1\\_105/A2\\_1\\_105\\_08637.html](http://lloydbleekcollection.cs.uct.ac.za/data/books/BC_151_A2_1_105/A2_1_105_08637.html), last accessed 25/01/2010.
- [8]. <http://ocw.mit.edu/courses/anthropology/>, last accessed 01/06/2010.
- [9]. Callaway, H, *The religious system of the Amazulu*, Struik, Cape Town, 1970.
- [10]. Berglund, AI, *Zulu Thought Patterns and Symbolism*, C Hurst, London, 1976.
- [11]. Monteiro-Ferreira, AM, *Reevaluating Zulu Religion: An Afrocentric Analysis*, Journal of Black Studies, vol. 35, no. 3, January 2005.
- [12]. Werner, A, *Myths and Legends of the Bantu*, Bibliobazaar, Charleston, 2007
- [13]. Couto M. *Voices Made Night*. Heinemann, 1986.
- [14]. Van Vliet, H, *Software Engineering Principles and Practice*, John Wiley & Sons, West Sussex, 2008.
- [15]. McLennan-Dodd, V, *The Healing Land: Research Methods in Kalahari Communities*, Critical Arts: A South-North Journal of Cultural & Media Studies, vol. 18, no. 2, pp. 3-30, 2004.
- [16]. Holden, P, *Conservation and human rights - the case of the Khomani San (bushmen) and the Kgalagadi Transfrontier Park*, South Africa, Policy Matters, vol. 15, no. July, pp. 57, 2007.
- [17]. Palgrave KC, *Trees of Southern Africa*, 2<sup>nd</sup> Edition, Struik Publishers, Cape Town, 1977.
- [18]. Canadell, J, Jackson, RB, Ehleringer, JR, Mooney, HA, Sala, OE & Schulze, E, *Maximum Rooting Depth of Vegetation Types at the Global Scale*, Oecologia, vol. 108, no. 4, pp. 583-595.
- [19]. [Carte, AE, Anderson, RB & Cooper, MA, *A large group of children struck by lightning*, Annals of Emergency Medicine, June 2002.
- [20]. [www.megger.com/es/story/index.php?ID=127](http://www.megger.com/es/story/index.php?ID=127), last accessed on 16 November 2009.
- [21]. [www.smeter.net/grounds/soil-electrical-resistance.php](http://www.smeter.net/grounds/soil-electrical-resistance.php), last accessed on 16 November 2009.
- [22]. Geldenhuys H, *Lightning protection for electronic systems*, CSIR Conference Centre, CSIR, Pretoria, 1990.