GP3

PROPOSAL TEMPLATE FOR THE IMPLEMENTATION OF AFRICAN CENTRES FOR LIGHTNING AND ELECTROMAGNETICS (ACLE)
August 2014

EXECUTIVE SUMMARY

By considering,

the marked increase in reports of lightning related deaths and injuries in Africa over the last few years of which the majority have been in rural areas and;

the unacceptably high rate of property & equipment damage and data & information losses that results in failures of vital systems at critical operational cycles and downtime causing negative economic impact in Africa at all levels and;

the dangerous level of misinformation and unsafe lightning related products / technologies which have started reaching the public in many countries in Africa, creating safety risks;

the Centre for Science and Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre) adopted a resolution at the African Regional Training Program on Lightning Protection on the 7th of February 2013 to form the African Centres for Lightning and Electromagnetics (ACLE). The originally proposed title of the Centre has been slightly modified to benefit from experiences at other centres of excellence in the world.

The ACLE is proposed to be established in a suitable university, public institution or any relevant organisation. Following are the general objectives of the ACLE:

1. Develop research groups in electromagnetics, lightning protection, high voltage and grounding technology, characterization and physics of lightning, societal aspects of lightning, lightning education, health risks and medicine, etc.

2. Develop and conduct PhD, MSc, Diploma level and short courses on electromagnetics, lightning and related subjects.

3. Train educators, broadcast meteorologists, media, and trainers in lightning safety, health and medicine with the aim of minimizing lightning accidents in African region.

4. Collect information on lightning incidents, injuries and damage in African regions and develop databases that are easily accessible to the public.

5. Develop networks at various professional and social levels (engineering, technical, schools and other academic units, social workers, etc.) to conduct appropriate technical training and safety awareness programs, seminars, conferences and other promotional activities.

6. Assist Standards Institutions/agencies and other government bodies in adopting IEC Standards (IEC-62305: 2010) and internationally recognized standards in relevant fields with appropriate modifications to suit the specific African country.

7. Seek financial support and recognition for ACLE from relevant organizations.

8. Seek financial support from international agencies for research, awareness promotion and capacity building (e.g. NORAD, ISP/SIDA/SAREC, ERASMUS MUNDUS and EC, UNESCO, USAID, TWAS).

9. Initiate, coordinate and assist other national lightning and electromagnetic institutes/departments/branches in the country and across Africa.

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1. LIGHTNING ENVIRONMENT IN AFRICA

For the last decade, one can clearly recognize the increased occurrences and reporting of lightning related effects to both the industrial sector and the civil life in Africa. Most importantly, lightning causes human casualties. Lightning ignites fires that may bring an entire building or a house down to ashes. At a lower degree of damage, the lightning current may destroy essential electrical, electronic and communication equipment beyond repair. However, one of the most significant loses that lightning may cause, as far as industries are concerned, is the downtime. A few hours of interruption to normal operation or the loss of important data stored in a computer may cause a company economic losses of several million dollars. A brief review of the science of lightning has been given in the Appendix.

Global lightning occurrence maps,[13] based on satellite data, show that many parts of African continent have the highest lightning densities in the world. However, until recent decades, the international community hardly received information on the severity of lightning accidents in the 'Dark' Continent. Perhaps because it was a televised game, the first major lightning accident in Africa, reported in 1998, was an incident where 11 players of a single football team were killed by lightning in the Eastern Province of Kasai in Democratic Republic of Congo (World: Africa Lightning kills football team, BBC News, 28th October 1998). The original news report (L'Avenir/Kinshasa) stated that more than 30 spectators had received severe burns whereas the players of the other team who were in the field with the victims came away unscathed. Although scientific papers have been written about the theoretical mechanisms of injury in this disaster, the actual details of the incident were never investigated as the region of incident was inaccessible due to civil unrest in Congo.[2,3]

Many other disturbing reports on lightning incidents in Africa have been published since the Congo incidents. A few accidents reported only during year 2010/2011 include.

- 25 people being killed during a one month period in June/July 2011 in Tigray, South West region of Ethiopia ("Lightning kills 25 amid extensive drought in East Africa", Sudan Tribune, 27th July http://www.sudantribune.com/spip.php?article39542

- 20 people in Kenya were killed by lightning within one week in June/July 2011, including all 8 members of a family who were affected by a single strike ("Kenyans Alarmed as Lightning kills 20 people within one week", Julalo, 05th July 2011); http://blog.jaluo.com/?p=21002

- 15 people were killed by lightning during one weekend in January 2011 in KwaZulu-Natal, South Africa ("South African politician says number of lightning deaths is rising", The Guardian, 04th January 2011); http://www.theguardian.com/world/2011/jan/04/south-african-lightning-deaths

- Seven school children between the ages of 10 and 13 were killed when lightning struck the thatched roofed structure where they were attending a Quranic school in the remote village of Sarguilla in southern Darfur, Sudan ("Lightning kills 7 school children in Darfur", Gulf News, 17th August 2010); http://gulfnews.com/lightning-kills-7-school-children-in-darfur-1.669400

- Nineteen people were killed within a single day in Gombe, Yobe and Bauchi states in Nigeria ("Lightning Kills 19 in Gombe, Yobe, Bauchi - Man Loses Two Wives, Two Children", Vanguard, 29th June 2011); http://allafrica.com/stories/201106300254.html

- Three children were killed and 10 people were injured when lightning struck an outdoor gathering in Bigogwe sector in Nyabihu District, Rwanda ("Lightning Kills Three Children", The New Times, 28th June 2011). http://www.newtimes.co.rw/news/views/article_print.php?i=14670&a=42644&icon=Print

The above examples are only a sample but indicate that the risk of death and injury by lightning in many African nations is either equal or greater than that in several regions of the world that have been reported in literature.[1, 4-6, 8-12, 14-16]

Lightning damage and injury pose a definite threat to a continent that is set to achieve rapid industrialization. Electrical power grids and aviation, essential to the economic growth of the African continent, are especially vulnerable to lightning damage. Although the explosive use of electronic devices in Africa will increase damage, it also provides a golden opportunity to use mobile networks for warning and injury prevention education. The effect of increased urbanization of the population is well known, but lightning risk due to modification of the atmosphere by high rising buildings and artificial activities has yet to be studied.

2. THE URGENT NEED FOR ACLE

2.1 The deaths and injuries that could be avoided

Every year, scores of people in African continent are killed by lightning. Although reliable statistics are not available at present in most African countries, recently reported information from a few countries suggests that the African continent may have more lightning incidents per country and per population than any other part of the world. In Africa, most of the people killed by lightning are villagers in rural areas working in open fields and children in unprotected schools. Both of these populations are often vulnerable because they work in the open and may walk unprotected for great distances to markets or school. The lives of many of these people could have been saved if they were given proper education in lightning protection.

Apart from human injuries and deaths, the innumerable deaths of animals caused by lightning every year can have a great impact on individual families. Such incidents incur heavy losses on the livestock industry in the region and could be minimized by educating the people regarding basic lightning safety measures for livestock.

2.2 Destruction of property and the impact on industry

Properties worth many million USDs are damaged in the power, communication and industrial sectors and at domestic level during lightning seasons each year. This does not take into account the billions of dollars of indirect losses due to downtime caused by the damaged and malfunctioning equipment or from loss of data in the microprocessors. A recognized example of this is banking and other financial institutions. Increasing equipment damage is expected over the next few decades due to the wide spread the use of electronics, extension of the national power grid into rural areas and the mushrooming communication towers all over the country. These types of economic loss due to a natural hazard are largely avoidable and provide an unacceptable risk for any country in the process of fast economic growth and industrialization.

2.3 Protection of Archaeological sites

Another very important and grave concern in Africa is the safety of archaeological monuments from lightning damage. At present, these irreplaceable and highly valued structures and sites are often either totally unprotected or improperly protected. Typically, many of these structures are at greater risk than other structures because they have been erected well above the flat terrain or built on isolated rocks or mountains, making them highly vulnerable to lightning, which tends to hit high or isolated objects. In some cases, the situation has been worsened by the erection of metal structures for various purposes in the vicinity of these monuments by archaeological departments who do not have knowledge of the often increased risk these impose, particularly if the structures do not have proper grounding systems. If these sites are of value to a country and their people, risk evaluation and installation of proper lightning protection is essential before any of these suffer irreparable damage

2.4 Need of Recognized and Valid National Standards on Lightning Protection

Lightning Protection & Safety is a field that requires high specialization for an electrical engineer to become an expert. At present, many engineers in Africa who are involved with lightning protection have only a vague knowledge in this unique field although they may be very competent in general electrical engineering. Simply, many of them either simply sell products they import from other countries or forward recommendations to the relevant administrators to buy and install the products.

Unfortunately, as in many fields of endeavour with a highly technical component, scientifically unproven or inadequate technologies as well as fraudulent claims for these devices can appear to be reliable to an unwary person. Even the best intentioned engineer, architect, installer, or government official may not have the expertise or time to evaluate vendor claims. Thousands of dollars can be invested in products that would be unacceptable under building codes in more developed countries. Even more dangerous is the false sense of security for workers and businesses where these devices are installed. A careful analysis of the present market in lightning protection would reveal the widespread use of inadequate or untested protection systems.

Fortunately, Lightning Protection Standards based on scientific data have been formulated by panels of internationally recognized lightning experts. Some of the recognized standards include the International Electrotechnical Commission Standards (IEC), British Standards (BS), Australian National Standards, and American Standards (ANSI). The adoption of international standards or the implementation of lightning standards consistent with recognized international standards by individual countries or regionally in Africa is essential.

ACLE will work with countries wishing to adopt accepted standards to provide consultation and advice as well as to provide training courses for engineers, architects and lightning protection professionals.

Africa's engineers, despite their best intentions and efforts, are at a distinct disadvantage if they do not have access to this knowledge and training.

2.5 Lack of knowledge of the public

In some countries, lightning injury prevention education has yielded amazing results in decreasing lightning deaths and injuries.[7,17] Most developed countries have decreased risk because they are located in temperate areas which tend to have lower lightning strike density. They also have substantial housing that has plumbing and wiring in the walls of the structure and fully enclosed metal vehicles, both of which are very safe from lightning for the inhabitants. Africans are at increased risk for many reasons:

1. Location in tropical and subtropical areas with very high lightning strike density
2. Labor-intensive agricultural, construction, and other occupations which give little or no shelter
3. Homes, businesses, schools, churches and other structures that do not provide adequate protection and, in some instances, may actually increase the risk of injury
4. Large areas of savannah and other geographies that give high exposure and offer no protection
5. Fewer totally enclosed metal vehicles per population
6. Belief in folk myths that may provide a false sense of security or, in some instances, actually increase risk of injury

In developed countries, the media has been invaluable in educating the public and may also be useful in Africa, both by publicizing events which raises awareness of the danger and by giving public education through newspaper stories, weather broadcasts, new programs, documentaries, and other programs. Educators, coaches and other leaders can be invaluable in giving information and in modelling lightning safety behavior.

2.6 Lack of high voltage laboratory facilities for testing and research

At present, both building and surge protection devices imported to Africa are trusted upon the test certificates issued at foreign laboratories. The local distributor has no way of verifying the claimed properties of the products due to the lack of test facilities in Africa. Even more importantly, regional scientists and engineers, who may invent devices for lightning protection, are at great disadvantage because they do not have facilities to verify the performance of their products. The cost for testing their products at a foreign laboratory, usually in a developed country, may be immensely high and beyond the reach of most innovators in Africa. As a result, they may be unable to introduce their products to the market or to compete successfully with devices that have fancy seals or other promotional claims.

It is also nearly impossible for universities in the region to offer undergraduate and graduate programs in high voltage engineering and discharge physics due to the unavailability of high voltage laboratories and trained experts in the region that could provide research facilities and training adequate to support these programs.

2.7 Lack of knowledge on African Lightning

Almost all the products related to lightning protection that are available in Africa have been produced to withstand the characteristics of lightning currents and lightning generated fields measured in temperate regions and sub-tropical regions. A considerable number of scientists believe that characteristics of tropical regions may be different than observed in these areas. Little scientific research has been done in the tropical African regions to analyze lightning data. Trained, expert lighting scientists are needed in Africa to study these areas of physics and engineering.

2.8 Need of an independent body to check and approve lightning protection installations and import of products

In Africa, a majority of those seeking lightning protection have little knowledge in lightning protection. They are at the mercy of vendors and inadequately trained engineers, architects and others regarding both protection devices and system installation. Training of lightning protection specialists, adoption of lightning protection standards for buildings and an independent body of reputable professionals and academics to investigate existing available lightning protection products and installations is urgently needed in Africa.

2.9 Requirement of a region-wide network for lightning detection

In almost all developed countries and in many newly industrialized and expected-to-be industrialized countries, a lightning localizing/mapping system has become an essential part of the day-to-day operations of civil administration, aviation, communication, utilities and military defence. Lightning localizing systems are an essential part of any region that proposes to pursue industrialization and economic advancement. The absence of a total lightning detection system may be a primary cause of weather related aviation incidents that have occurred during the last decade over Africa. In addition, the need of a lightning detection system is urgently needed in meteorology, the power sector, communication sector, industrial sector, defence, hydrology, ports & fisheries and other industries that are affected by lightning.

3. OVERVIEW OF ACLE

One solution to the issues mentioned above is the implementation of a pan-African organisation on Lightning and Electromagnetics. The proposed organisation shall be composed of independent national centers with one over-arching vision but mission statements adopted to suit national priorities. National centers can be implemented as a part of faculty / department / school / college, non-profit organization, designated government body or other relevant and appropriate organisation. The host institution, in collaboration with the appropriate engineering and scientific bodies, should take the initiating steps in opening the national centres.

3.1 General objectives of the pan-African organisation

The objectives of the pan-African organization and national centres include:

- **a.** Conducting research related to meteorology, physics, engineering, health, education, environment and other societal impacts of lightning and electromagnetics.

- **b.** Developing and conducting PhD, MSc, Diploma level and short courses on electromagnetics, lightning and related subjects.

- **c.** Training educators and trainers in lightning safety, healthcare and medicine with the aim of minimizing lightning accidents in Africa.

d. Collecting information on lightning incidents, injuries and damage in Africa and developing databases that are easily accessible to public.

e. Educating and training the engineering, technical & scientific communities in lightning protection through long term and short term courses.

f. Assisting in the initiation, enhancement and sustenance of other national lightning and electromagnetic centres in the region.

g. Assisting relevant authorities in the implementation of national/regional Standards in Lightning Protection, adoption of IEC or other internationally recognized standards at national/regional levels, and promoting the standards among the engineers and general public.

h. Raising public awareness of the dangers of lightning. Educating the public about lightning protection, injury prevention and safety at the local and regional levels through seminars, workshops, demonstrations, meetings, media discussions, leaflets and booklets, posters, billboards, warning signs, and other appropriate and effective educational tools.

i. Educating medical professionals about lightning injury and injury prevention.

j. Providing high voltage laboratory facilities for testing of lightning protection devices, electrostatic discharges and other related studies for manufacturers, vendors, researchers and university undergraduate/graduate programs in Africa.

k. Providing consultancy on lightning protection to the public.

l. Coordinating collaborative research between academicians and the industrial sector.

m. Searching for international funding on lightning protection and channelling the funds into regional research projects as appropriate.

n. Undertaking research and development of commercial projects for lightning protection.

o. Acting as the authoritative body for monitoring lightning protection equipment imported to the region.

p. Acting as the authoritative body for approving lightning protection systems installed at government institutions in the country.

q. Acting as the authoritative body for investigating and monitoring institutions that cause unacceptable levels of electromagnetic pollution in the environment.

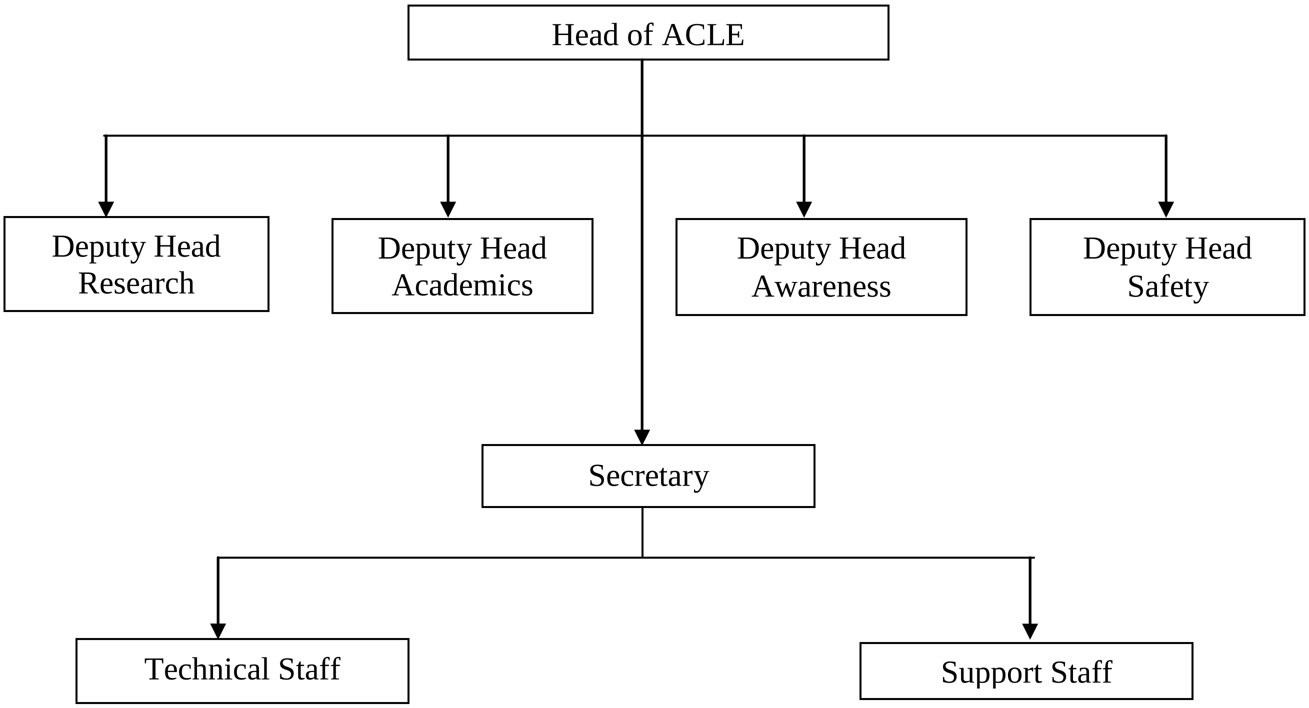
r. Acting as the authoritative body for investigating and monitoring the adverse effects of lightning on the neighbourhood by high rise structures such as communication and broadcast towers, storage tanks, tall buildings, etc.

3.2 Structure of operation of the proposed institution

The national ACLE shall be a body corporate recognised as such under the laws of that country. This is important in decision making. Accordingly, where it applies and resources permit, it is generally proposed to operate a national ACLE with an appropriate administrative structure and Board of Directors.

3.2.1 Administration

The Administration, led by the Head of ACLE, executes all operations and implements policy decisions taken by the BOD. A possible administrative tree for the national ACLE could be:



3.2.2 Board of Directors (BOD)

The BOD makes policy decisions that affect both planning and implementation of operations of the ACLE. The BOD will be crucial in making decisions that bring benefits and promotion to ACLE. The BOD should coordinate closely with Administration for smooth operation of the ACLE. Ideally, the Head of ACLE should be a member of the BOD, possibly as secretary. Possible composition of the BOD is:

Chairperson – A suitable senior academic or person with relevant background.

Head of ACLE, acting as secretary of BOD

Director – From S&T Ministry/Department or Meteorology

Director - From Education Ministry/Power sector/Health

Director – From Disaster Management Sector/Defence/Private Sector

3.2.3 Infrastructure of ACLE

For long term success, the following infrastructure is highly desirable for smooth and complete operations of the Centre. However, it should be emphasized that it may be necessary for the Centre to be launched at the beginning with only a moderate space and bare minimum infrastructure facilities.

a. General administration unit
b. ……………….. ……………….
c. ……………….. …………………

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APPENDIX

A1. Basics of Lightning

Lightning is a natural atmospheric phenomenon which is caused by the instability of charge distribution within a cloud. It can also occur due to charge separation in masses of ash and dust ejected in a volcanic eruption or a nuclear explosion. Lightning physics is the study of the various aspects of lightning, such as background conditions for formation, corresponding activities, variation, and distribution based on geographic location and effects on human beings & structures.

A lightning flash originates inside a cloud several kilometres above the ground level. Except for ball lightning, which is a very rare phenomenon, lightning is simply an electric spark between a cloud and the ground (CG), between two clouds or between two parts of a cloud (IC). The spark that jumps between the ends of two wires which are connected to the terminals of a car battery is a very basic form of lightning.

In the first stage of the lightning strike, channels of charge flows between regions of a cloud or between clouds. Eventually, one of these channels may begin to flow towards ground from the cloud. When this channel is about 50-100 meters above the ground, opposite charges are induced in any earthbound objects in the vicinity including trees, towers, buildings, human beings, animals, blades of grass, and so on. When these channels are strong enough, they begin sending channels of opposite charge upward to meet the downward channel from the cloud. Lightning most frequently, but not always, connects to one of these upward channels coming from a tall, isolated or pointy structure within about 50-100 meters of the tip of the downward channel. Subsequently a large current will flow through and around the object which sent the connecting upward channel. We can say that the object 'was struck by lightning'.

In the frontiers of lightning physics, a number of research groups in Europe, North America, and Australia conduct investigations on the characteristics of lightning currents and lightning generated electromagnetic fields, detection of lightning activities from its early stages to the time of strike, and lightning induced voltages and currents in service lines and structures. At several sites, scientists use rocket-triggered lightning flashes to study various lightning characteristics. The long-gap discharges generated at high voltage laboratories can also be used to investigate some lightning features that cannot be easily tested under real atmospheric conditions. The goals and objectives of many of these studies are to enhance the knowledge and understanding of nature and to improve the scopes of engineering such as lightning protection and electromagnetic compatibility.

A2. Damage caused by Lightning

Lightning may cause damage to buildings and equipment in three ways:

A.2.1 When a building is hit by a downward lightning leader (direct strike) or a part of a lightning flash that hit another structure in the near proximity (side flash) it will get the maximum damage. The lightning current reaches a maximum value of about 30,000 Amperes on average but currents in the range of 300,000 Amperes have also been reported. The enormous current involved with the lightning flash may destroy the entire power and communication network in a building including all the equipment connected to the network.

The lightning current heats its path to a temperature of about 40,000 Celsius. The high temperature resulting from the current flowing in the lines and the sparks that jump in between different parts of the building may trigger fires that can burn and sometimes completely destroy the installation. Direct lightning and side flashes cause damage at such a rapid rate that, once the building has been struck, it is very unlikely that anything can be done to prevent damage to the equipment and inhabitants, although spreading of the fire can be prevented with quick action.

A.2.2 The second mode of lightning currents entering an installation is through the service lines such as power, communication, and cable TV or plumbing. Once lightning strikes a service line, fractions of the lightning current enter all the nearby buildings and may destroy equipment that is plugged into the system. The lightning current may also injure people using equipment connected to service lines. While this mode of intrusion of the lightning current may cause less damage than a direct strike, service lines are subjected to lightning strikes much more frequently than the buildings themselves.

A.2.3 The lightning current that flows from cloud-to-ground is a good emitter of electromagnetic radiation. When lightning hits a nearby object (say at 500m), the building may be exposed to a strong dose of electromagnetic radiation. When this radiation passes through electronic equipment such as computers, control systems, medical equipment, and military equipment, sophisticated parts can be destroyed. This electromagnetic effect may damage equipment even when it is not plugged into service lines. While the chances of ordinary electrical equipment being damaged due to such radiation are very small, protection of equipment that is essential to critical functions or life support may be considered.

A3. Building protection against Lightning

In commercial language, a network that is meant to protect a building from direct lightning strikes and side flashes is referred to as a Lightning Protection System. An ordinary building protection system consists of three parts:

1. Air terminals - one or several sharp pointed rods (or a mesh of metal strips/wires) installed at the roof of the building
2. Down-conductors - several properly bonded and configured metal strips or metal wires from the roof air terminals to earth conductor, usually at the base of the building
3. Earth conductors - one or several conducting rods buried in the ground that can provide safe dissipation of the lightning current around the building

The down conductor system connects the air termination to the earth conductors. When a downward lightning channel comes from a cloud, the air terminals send upward channels much faster than the other parts of the building so that lightning is more likely to hit one of the rods (or to the metallic mesh). Down-conductors insure that the lightning current is safely passed into earth through the rest of the system.

Lightning systems neither repel nor attract lightning. However, if lightning is going to hit the building anyway, they provide a safe conduction path for the current around the building to prevent damage. This system is called the "Franklin Rod System", named after Benjamin Franklin who first proposed lightning rods in 1749.

A4. Surge protection

The Franklin Rod System protects a building only from direct strikes and probably from side flashes. Unfortunately, the building can be penetrated by lightning currents that propagate along service lines (power, telecommunication, cable TV, etc.) and plumbing. These lines are actually more likely to be hit than individual buildings because they usually stretch a long distance over the land. Special devices called surge diverters and surge suppressors can prevent these current impulses from entering a building.

A surge diverter is usually connected at the entrance of the service line to the installation. For buildings which require a very high level of protection, such as munitions factories or companies like banks that have sensitive electronic financial information, surge diverters may be necessary at the power socket of each electric or electronic equipment as well. Under normal operation, the surge diverter does not interfere with the line signals. In the case of a lightning invasion, it provides a convenient path for the lightning current to divert into the earth without permitting it to enter into the actual building or the equipment.

Surge suppressors, which have to be connected to protect power lines, communication lines and data lines, are different. Equipment in a building may be damaged not only due to lightning induced voltages but by impulses generated within the building itself during on-off process of large inductive loads (heating and cooling) and operation of copiers, scanners, elevators, etc. Surge protection against lightning is inherently merged with the protection against these artificial voltages termed switching impulses. For homeowners and small businesses who may not need or cannot afford sophisticated lightning surge protection, it should be noted that surge protection strips that are commonly available at hardware stores may protect well against the common surges, but are usually not designed to protect against lightning surges. It is often easier and simpler to unplug the equipment from its source of electricity.

A5. Electromagnetic Compatibility (EMC)

The sophisticated electronics in a building can also be damaged by electromagnetic radiation emitted from the lightning flash. Electromagnetic radiation propagates in free space but can be prevented from entering a building with suitable protection measures. The typical method of radiation prevention is to screen the building with a conductive material so that the building becomes a "Faraday Cage".

Since it can be unnecessary and very costly to screen entire buildings, it is recommended that safety measures be applied only to compartments of the building where sophisticated electronics are installed such as computer rooms, medical theatres and scanning rooms, control chambers of power plants, airports, military bases, communication bases, etc.

Design and implementation of protection systems that prevent the intrusion of undesired electromagnetic impulses through both radiation and conduction is termed Electro-Magnetic Compatibility (EMC). This newly emerged field of electromagnetic protection has become a huge business in many developed countries but is hardly known in Africa.