Use of lightning data services in the industry

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Abstract: This paper presents existing lightning data services that can be use as part of a lightning prevention approach and the result of a study of the use of lightning data services by industrial users. The study takes into account the reasons for choosing a lightning prevention approach, the benefits of this approach and its success factors.

Keywords: Lightning service, lightning risk prevention, early threat warning.

1. Introduction, Lightning data, from research to industrial application

The research community has been involved with lightning for hundred of years. The study of the lightning discharge, the climatology of storms, the injuries to human beings are some of the domains where an active research activity takes place. Lightning detection networks are one of the by-products of this research. They provide a wealth of information, from real time tracking of storms to single flash characterization and statistical analysis of lightning evolution. Meteorologist and utility operators, requiring skilled personnel to interpret and use the information they provide, mainly use those networks.

Recently, lightning data services has been designed to provide industrial customers with specific solutions to reduce the lightning induced risks on their operations.

Although those services will not protect against the occurrence of lightning, they allow to modify the operational configuration of plants or recreational parts, and to decrease the lightning damages and to control the quality of the protection devices.

2. Risk prevention

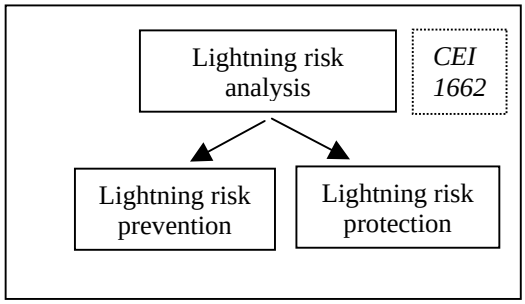
Risk prevention is a relatively new approach that has been developed with a focus on human activities and industrial operations.
Risk prevention of natural disaster has been widely publicized and enforced lately; it is based on the knowledge of the physical phenomenon and its impact on human organizations. The risk is assessed through the probabilistic analysis of a given risk occurrence and the potential damages associated with a single event.
Similarly, in the industry, risk prevention starts by identifying a given risk occurrence and limiting the consequences of a potential accident.

The outcome of a risk prevention approach is the definition and deployment of ad-hoc procedures.
The efficiency of risk prevention campaigns can be estimated by comparing the damages induced by the given phenomenon before and after implementing specific actions, taking in account the actual occurrence of the phenomenon.
To measure the success of such an approach, and to enhance its result, a feedback mechanism is installed that will allow to check the process efficiency and introduce new practices as the environment evolves.
Ultimately, the success of risk management depends on the cultural acceptance of a new behaviors and practices.

3. Lightning Risk prevention

Lightning protection techniques have been used in the industry for years, it is based on a well-established body of standards and rules, and it is the most current approach to reduce the consequences of lightning to industrial activities.
Lightning, although it is not necessarily evaluated as a natural disaster nor as a major risk is known to produce a high number of death and injuries, it can also produce important loss in material and equipments through fires and over-voltages. Indirect or secondary effects of lightning are also responsible for severe damages to installations. The downtime resulting from those accidents can be important, with direct effect on operations and financial results. Loss of production is also a consequence of failures. Lightning will also disorganize human activities through the correlated flash floods or through the urgent operations required to manage its immediate consequences, resulting again in operational inefficiency.
So the same principles put in practice for natural disasters and other industrial risks can and should be applied to lightning.

A good framework to consider lightning risk prevention has been proposed by SEE working group 44.30 dedicated to the methodological aspects of this domain.



The overall context is the fight against lightning aggression.

- Lightning risk analysis consists in evaluating the damage to persons, environment, equipment and operation that can appear as a consequence of lightning aggression.
- Lightning risk prevention is the set of activities aimed at adapting the operational procedures as a function of the detected lightning risk
- Lightning protection is the set of activities that act on the equipments, systems, installations and structures in order to enhance the resistance to lightning aggression

4 Lightning data services

The main lightning data services that can be used as part of a risk prevention approach are:

- **Lighting statistics**

Statistics can be computed on many different lightning parameters once a large enough database of information is available. Typically the lightning density (number of flash per km² per year) and the flash current distribution are computed for a given area and time period. This information allows characterising lightning occurrence in one region and comparing various regions or time periods.

Lightning statistics are generally used as an input to the risk assessment procedure. Figures such as the lightning density or isokeraunic level are taken in account in various models. This information is widely available and essentially stable over time.

- **Early threat warning**

Advance warning of approaching storms can be given by local detectors such as field mills or electromagnetic sensors, or elaborated and transmitted by a Lightning Location Surveillance System (LLSS) monitoring a given area. The warning information can be send to an operator that is allowed to apply ad-hoc procedures in order to take the protective actions and modify the operations in progress. Those procedures can cover the handling of dangerous products, isolation from the power lines, crew or personnel displacements. In some cases, the warning information can be automatically processed in order to modify a system configuration (start power generators and isolate from external utilities, …)

The early threat warning information is a part of the lightning prevention domain, allowing to reduce the consequences of an existing storm.

- **Real time visualisation**

The real time data provided by an LLSS can be analysed by an operator time in order to track the evolution of storms and adjust the operations of a plant or network. The information provided by the LLSS is more complex than the simple warning message described earlier, it is necessary to have some meteorological background in order to interpret a given situation and decide the relevant actions. A qualified operator is required.

This kind of organization, again part of a lightning prevention organization, is used when a large area is to be monitored and when important resources are at stake. Typically, such an organization is available in power line or telecom networks.

- **Lightning expertise**

The data provided by LLSS can be archived and used to verify the origin of fault. By checking the existence of lightning at the place and time when damage has been identified, it is possible to assess the origin of the fault and take the corresponding actions. This check-up process is used by insurance companies as part of their claim processing practice, but also by network operators in order to diagnose and correct a lightning induced fault. This process is used for post mortem diagnostics and lightning protection optimisation campaign on large networks.

Recently, industrial operators have started to use the information made available by the lightning expertise on a regular basis in order to set up a systematic procedure to check their installation after the occurrence of a storm. This approach is typically a feedback mechanism that allows controlling the behaviour of the system under actual stress.

5. The Lightning Alarm Service

Météorage, operator of the French Lightning Detection Network has designed an Alarm service, a typical early threat warning service, that allows to monitor it's customer's area and send a warning message when lightning approaches it.

The area can be as simple as a circle or be defined with a more complex shape in order for example to take into account the power lines feeding the site or the known displacement of the storms in the customer's region.

The warning messages are sent by automated process, by phone, fax or email. Customer specific agendas and scenario are defined and the messages convey dedicated operational instructions.

This warning message is the only information users will receive as part of the service; no flash information or real time display is available to them.

The service has been in operation for more than 10 years and today it serves about 150 clients under a yearly subscription contract.

A recent customer survey has been conduced and its results highlight some main benefits of the service.

The customer sample is segmented as follows:

Activity	**% Of customers**
Army	16
Chemical	12
Paper mills	12
Plastic	9
Automotive	8
Nuclear	6
Construction	6
Industry	6
Agriculture	5
Recreational parks	4
Space and aviation	4
Waste processing	4
Other	*8*

Even if two of the customers belong to distribution networks, they all operate single site installations.

Two preliminary questions allow identifying the reason to use the Alarm service.

Known sensitivity to lightning	**% Of expressed answers**
Electricity	35
Discontinuity of operations	23
Loss of equipment	19
Human risk	16

Only 2 customers did not answer this question. This shows that the sensitivity is well known and related to the site activity.

Reason to subscribe	**% Of expressed answers**
Material safety	35
Electric risk	27
Personnel safety	21
Regulation and standards	13

60% of the customer gave more than one answer, showing that the reasons to subscribe are multiples.

Some questions allowed characterizing the initial conditions:

76% of the customer had previous damage due to lightning.

98% of them estimate the lightning risk from fatal to important. When the cost of a failure was given, it was many orders of magnitude higher than the cost of the service.

80% have an alternate power supply

The usage of the delivered information establishes as follows:

Operational procedure	**% Of expressed answers**
Isolate from utility, stand alone	45
Stop activity	24
Monitor the situation	7
Evacuation	6
Other	*17*

Service availability: 93% of the customers use it 24/7

It can be noted that if 80% of the customers have an alternate power supply, only 45% of them use the warning information to isolate their site from the utility network.

6. Future trends

The current experience of Météorage with its Alarm customer base shows that once a subscription is set up it is rarely cancelled. The Alarm service becomes embedded as part of the operational practices and cannot be abandoned.

The pressure to use best practice and obey the principle of precaution will surely lead to the development of the use of security services in general and lightning warning in particular. The flexibility and capability to reconfigure the operations of a plant will give more opportunities to define the action to be taken when a warning message is received. The general obligation to protect people and

show that all the possible protection mechanism are deployed will also extend the use of lightning warning services.

The very simple content of the information delivered as part of a lightning warning service, and the requirement for a foolproof interpretation of this information do create a need to raise the accuracy of the service in terms of warning delay, false alarm avoidance, end of alarm monitoring. The research community has a part to play in this evolution. Some possible directions for future investigations could be:

- Identifying the maturity phase of the clouds in order to predict their end of life.
- Combining other elaborated meteorological information such as wind fields to nowcast the displacement of the storms

7. Conclusions

A general segmentation of the industrial users of lightning data services in the industry would be:

- Mature customers

  They have a risk management approach and a lightning protection system in place, they are willing to enhance they immunity level and are ready to modify their operational procedures to do so.

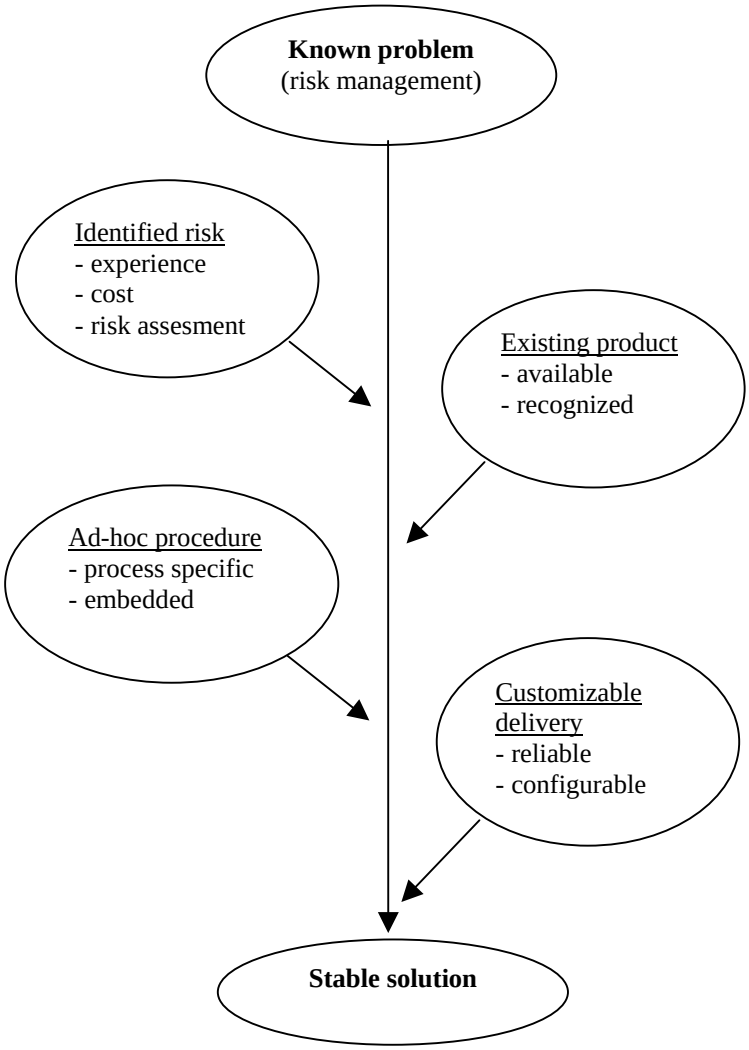
- Accessible customers

  They will follow best practices, accept recognized solutions and listen to risk reduction advantages.

- Reluctant customers

  They will consider lightning prevention only when required by regulation and standards

Our market study shows that a well-defined and customisable lightning warning service finds its place in a lightning prevention approach. The availability and reliability of the service are of prime importance, but the customer's perception of the service benefit is also a prerequisite for it success. Ultimately the definition of the customer's processing of the warning message will be the key success factor in the development of this service. This will imply a fine knowledge of the customer's constraints, operations and organization. The following diagram represents the overall success of the service:



We believe that the over simplified information delivered to the end-user of the Alarm service can be trusted and used only if the credibility of the overall system in charge of producing the warning message is established and perceived. The wealth of information provided by the detection network, the knowledge of the lightning phenomenon, the capability to customize and add value to existing products, the experience of the operators, the quality and reliability of execution are key elements to ensure the long lasting success of simple end user products.

8. Acknowledgment

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9. References

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